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EFFECTIVENESS AND ACCEPTABILITY OF NUTRIENT SOLUTIONS IN ENHANCING FLUID INTAKE IN THE HEAT

U S ARMY RESEARCH INSTITUTE
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Two colored, flavored, 2.5% carbohydrate-electrolyte solutions (Armyade and NBC Nutrient solution) with varying levels of magnesium, potassium, and phosphorus were tested for ad libitum consumption and acceptability during 8 days of work in a hot environment (max T_{amb}=31-38°C). Sixty-one male and female soldiers were divided into 4 test groups. A Control group drank water while the remaining three groups were given one of the following test beverages: NBC Nutrient solution, Armyade, or a colored flavored water (placebo). All four groups were allowed to consume other fluids such as plain water, soda, juice, etc. Acceptability in terms of hedonic ratings and consumption rate was determined. Two subjects absolutely refused to drink the assigned test beverages (Armyade and Placebo) after the first day, but did rate their acceptability at the end of the study. The data on the acceptability of the test beverages and demographics were assigned to the appropriate groups for these two subjects, however, the biochemical, hydrational, food, and fluid consumption data were analyzed as if these two subjects belonged to the Control group. There were no group differences in terms of energy intake.

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The subjects in the NBC group had a signficantly higher ($p<0.001$) average daily fluid intake than those in the Armyade group, but their intake was not significantly greater than that of the soldiers in the Control (water) or Placebo groups. Under conditions of light-moderate activity, moderate heat stress, and when other colored flavored beverages are available, there is no evidence that carbohydrate-electrolyte beverages will enhance fluid consumption over plain water. However, partitioning the total fluid intake for each subject into Colored Flavored Test Beverage (CFTB), Water, and Other fluids for the Armyade, Placebo, and NBC (not Control group since the test beverage had been plain water) groups, indicated that consumption of the CFTB was significantly greater ($p<0.001$) than Water and Other fluid consumption, with subjects in the Placebo group drinking up to 10 times as much CFTB as Water.

The daily hedonic ratings for the test beverages were: NBC Nutrient solution (6.7), Placebo (6.6), Water (6.5-rating by Control group only), and Armyade (5.1). The hedonic ratings of acceptability did not decrease with ad libitum ingestion during the 8 days. On a daily basis, the subjects in the NBC and Placebo groups rated their test beverages as more acceptable than the water rated by the Control group, drank more of these test beverages than water, and had lower incidences of hypohydration. The subjects in the NBC group rated their test beverage significantly higher than the subjects in the Armyade group rated their test beverage, drank significantly more fluid on a daily basis, and had significantly lower incidences of hypohydration.

Urine specific gravity and electrolytes, body weight, and fluid intake were monitored twice daily to assess hydration status. Urine specific gravity displayed a diurnal periodicity, with morning values higher than those in the late afternoon. The Control group had the highest incidence of urine specific gravities ≥ 1.030 (22%) whereas only 8% of the samples from the Placebo group had urine specific gravities ≥ 1.030 ($p<0.05$). Increased heat stress elevated urine specific gravity in all groups despite enhanced fluid intakes. On the hottest day, incidence of urine specific gravities ≥ 1.030 peaked in the Armyade (33%) and Control groups (34%); significantly lower ($p<0.05$) incidences were observed in the Placebo (8%) and NBC (0%) groups. Individuals having urine specific gravities ≥ 1.030 consumed about 22% less fluid than those with urine specific gravities <1.030. Likewise, urinary creatinine concentration obtained the morning after the hottest day were significantly greater for the Armyade and Control groups compared to the Placebo and NBC groups. Urinary sodium and potassium mirrored electrolyte ingestion. The NBC and Placebo beverages were effective in reducing the incidence of hypohydration by enhancing fluid intake during field exercises in hot climates. When food intake is adequate, the carbohydrate-electrolyte beverages are not necessary to provide electrolytes but may be helpful in improving fluid intake. According to the clinical chemistries, ingestion of the carbohydrate-electrolyte solutions was not accompanied by deviation from physiologically normal values. Drinking NBC and Armyade solutions appeared to be safe under the conditions studied.

In climatic extremes weather has a profound effect on soldier performance and drinking requirements. The ability to measure heat stress levels across a large area would provide valuable information for optimizing soldier performance. The close correlation between field and satellite-derived WBGT readings during the field trial indicates significant potential for the use of satellite remote sensing technology to accurately assess WBGT in training/operational environments.

HUMAN RESEARCH and DISCLAIMER STATEMENTS

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

TECHNICAL REPORT

EFFECTIVENESS AND ACCEPTABILITY OF NUTRIENT SOLUTIONS IN ENHANCING FLUID INTAKE IN THE HEAT

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FOREWORD

Two carbohydrate-electrolyte solutions, NBC Nutrient solution and Armyade, were tested to determine their effectiveness in enhancing fluid intake. The major purpose was to prevent hypohydration in soldiers working in the heat over an 8 day period.

Another purpose of this study was to test the acceptability of a NBC Nutrient solution recommended by a National Research Council advisory committee for soldiers working in the heat wearing Nuclear, Biological, Chemical (NBC) protective clothing (MOPP4). In previous tests where hydration was forced, water was as effective as the NBC Nutrient solution in maintaining physiological and psychological performance for the first 12 hours. This test of the acceptability of the NBC Nutrient solution was to answer the question of whether ad libitum availability of the NBC Nutrient solution vs water would affect enhance fluid intake and prevent hypohydration.

A third purpose of this study was to test the acceptability and usefulness of Armyade in enhancing fluid intake during work in the heat and as a possible oral rehydration fluid for the treatment of diarrhea. Using the formulation of the NBC Nutrient solution as a base, extra electrolytes were added to expand the usage to include treatment of diarrhea. The possibility of replacing the NBC Nutrient solution with Armyade would provide the Army with a multipurpose solution that could improve soldier performance.

This technical report is a compilation of ten separate sections of physiological and sensory tests written by the individual authors. Each section contains its own methods, results, and discussion. The literature review, general methods, integrated summary, general conclusions, and general recommendations contain an overall view of the study. The figures, tables, and references are listed sequentially throughout the report.

ACKNOWLEDGEMENTS

The authors wish to express their heartfelt thanks to all the subjects and workers who participated in this study. There would not have been a study without the 61 officers and enlisted men and women of the 44th Evacuation Hospital, Oklahoma City, OK and Detachment 1 from El Paso, TX who committed themselves to finishing the project. A study of this magnitude would not have been possible without the complete cooperation of BG Ran Phillips, commander of the 807th Medical Brigade; COL Duane May, commander of the 44th Evacuation Hospital; and LTC Paul Boensch II, Executive Officer of the 44th Evacuation Hospital. The authors would like to thank Dr. Kenneth Rider, Director of the Pathology Laboratory, Wishard Memorial Hospital, Indianapolis, IN for analysis of the pre- and post-serum samples.

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ABSTRACT

Two colored, flavored, 2.5% carbohydrate-electrolyte solutions (Armyade and NBC Nutrient solution) with varying levels of magnesium, potassium, and phosphorus were tested for ad libitum consumption and acceptability during 8 days of work in a hot environment (max T_{amb}=31-38°C). Sixty-one male and female soldiers were divided into 4 test groups. A Control group drank water while the remaining three groups were given one of the following test beverages: NBC Nutrient solution, Armyade, or a colored flavored water (placebo). All four groups were allowed to consume other fluids such as plain water, soda, juice, etc. Acceptability in terms of hedonic ratings and consumption rate was determined. Two subjects absolutely refused to drink the assigned test beverages (Armyade and Placebo) after the first day, but did rate their acceptability at the end of the study. The data on the acceptability of the test beverages and demographics were assigned to the appropriate test beverage groups for these two subjects, however, the biochemical, hydrational, food, and fluid consumption data were analyzed as if these two subjects belonged to the Control group. There were no group differences in terms of energy intake.

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the Armyade and Control groups compared to the Placebo and NBC groups. Urinary sodium and potassium mirrored electrolyte ingestion. The NBC and Placebo beverages were effective in reducing the incidence of hypohydration by enhancing fluid intake during field exercises in hot climates. When food intake is adequate, the carbohydrate-electrolyte beverages are not necessary to provide electrolytes but may be helpful in improving fluid intake. According to the clinical chemistries, ingestion of the carbohydrate-electrolyte solutions was not accompanied by deviation from physiologically normal values. Drinking NBC and Armyade solutions appeared to be safe under the conditions studied.

In climatic extremes weather has a profound effect on soldier performance and drinking requirements. The ability to measure heat stress levels across a large area would provide valuable information for optimizing soldier performance. The close correlation between field and satellite-derived WBGT readings during the field trial indicates significant potential for the use of satellite remote sensing technology to accurately assess WBGT in training/operational environments.

INTRODUCTION

Heat casualties are sometimes a major problem when working in the heat. Unacclimated individuals working in the heat often lose more than 2% body weight from sweat. The resulting hypohydration can affect performance and recovery from physical activity (1-3). Dehydration causing greater than a 2% reduction in body weight will decrease plasma volume, increase osmolality, decrease stroke volume and cardiac output, increase heart rate, increase core temperature, and reduce sweat rate and cutaneous blood flow (2,4-10). Significant loss of water with accompanying losses of sodium (Na^+) and potassium (K^+) may predispose an individual to heat cramps, heat exhaustion, and heat stroke (3). Hypohydration can adversely affect discipline and morale which may lead to moroseness, aggressiveness, and obvious signs of fatigue (2).

Optimal performance of a fully acclimatized person, performing intermittent hard work in the heat, is achieved by continually replacing the water lost in sweat (4). Small frequent sips of water are recommended to prevent dehydration and its attendant hyperthermia (11). However, subjects drinking water <u>ad libitum</u> tend to delay drinking and then consume all their fluid at one time (2). Observers have reported that subjects will voluntarily dehydrate when fluid requirements are high, and water losses may exceed 2.0% body weight depending on the work-rest cycle (2,12,13). Adequate hydration helps maintain body temperature during exercise (3,4,14) in the heat. If sufficient water is ingested, core temperature is maintained at a lower level (4).

The optimal oral hydrating solution should (a) be absorbed rapidly from the digestive system allowing for maximal fluid delivery to the body and maintenance of an adequate hydration level, (b) provide carbohydrate to the blood thereby sparing

muscle and liver glycogen stores and preventing hypoglycemia; (c) provide carbohydrate that will not result in a significant insulin response; and (d) provide minerals to replace those lost during periods of heavy sweating (15,16).

Glucose concentrations as low as 5% by volume can retard gastric emptying (15,17-23) and reduce absorption of the ingested fluid. The volume of nutrient solutions emptied from the stomach is delayed as the osmolar concentration of the gastric contents increases. This delayed emptying of hyperosmotic gastric content can cause nausea and discomfort. Coyle (19) reported that plain water emptied 39% faster than a 5% glucose solution when the subject was at rest, whereas Neufer et al. (23) noted that water emptied 22% faster than a 5% glucose solution at 50-70% VO_2max. However, delayed gastric emptying has not been shown to result in performance decrements. The total carbohydrate delivered from a 5% carbohydrate solution is inadequate to meet the carbohydrate requirement of heavy exercise (24). However, continued ingestion of a carbohydrate solution can stabilize blood glucose levels and thus the work rate (4,25-32) when compared to water. Of equal importance, is the coupling effect of glucose, Na^+, and water absorption in the small bowel which is distinct from the normal absorption of salt (NaCl) in the brush border. Solutes such as glucose utilize an independent brush border carrier which permits one Na^+ ion to be absorbed with each glucose molecule entering the cell. The resulting flow of water enhances further NaCl absorption (solvent drag) (33).

Another factor that may affect performance is electrolyte balance i.e., sodium is important in preserving extracellular volume. Costill (34) described electrolyte losses in the sweat ranging from 40-60 mEq Na^+/L sweat. Excessive sweating results in large water losses but the electrolyte losses are much smaller (35). Researchers do not agree on the need for electrolyte replacement during exercise in the heat. Pitts

et al. (4) reported that replacement of salt hour by hour during heavy sweating has no demonstrable advantage for fully acclimatized men who receive adequate amounts of salt in their daily diet. Most research on salt replacement is for short periods of time (2-6 hours) (4,35) followed by a meal soon afterward and therefore salt replacement was not needed. However, moderate sustained activity for 24 hours in a hot environment (sweating 0.5L/hr) could cause losses of up to 12 liters of sweat and hence 480-720 mEq (11,040-16,560 mg) of Na^+ per day. Frizzell et al. (36) reported on two unusual cases of hyponatremia resulting from excessive consumption of dilute fluids (about 20 liters containing 196 mEq Na^+) during excessive sweating in ultramarathon running, and concluded that in a small minority of long distance runners some replacement of sodium is necessary. Americans usually ingest 2300-6900 mg Na^+/day when only 100-150 mg of sodium is needed to meet the physiologic needs of people who do not lose excessive amounts of fluid (37). Food deprivation caused by anorexia in the heat could preclude salt replacement. The possibility of sustained exercise which can elicit hyperthermia (14,38), excessive fluid loss due to heavy sweating, and lack of regular meals suggest that sodium supplementation during the first 3-5 days may be important for unacclimated persons.

About 60% of the Mg^{++} in the body is in the skeleton. The remainder is chiefly in the intracellular space where it is involved in: (a) membrane permeability and transport, muscular contraction, and nerve impulse conduction; (b) intracellular fluid regulation such as viscosity, buffering, phosphate (PO_4) transport, activation of enzyme systems, activation of adenosine triphosphatase, and actions as a chelating agent; and (c) regulation of protein synthesis (39). There is evidence that Mg^{++} has an important role in maintaining cell K^+ integrity (40). Magnesium is pivotal in restraining the loss of cell K^+ during K^+ depletion (41) as well as in repleting cell

K^+ (42). Thus, avoidance of a Mg^{++} deficiency is important in order to circumvent the problem of refractory or resistant K^+ repletion (43,44). While body Mg^{++} is fairly well conserved by the kidney, losses may occur in sweat or diarrhea. About 1 liter of sweat contains about 1.5 - 5.0 mEq of Mg^{++} (34,45); therefore, soldiers sweating heavily in the heat and not eating regular meals may become depleted. If consumed, the average American diet is nutritionally adequate in its Mg^{++} content. A recent study of soldiers eating 3 A-ration meals per day in the field found magnesium intakes of about 414 mg/day (46). The Military Recommended Dietary Allowances (MRDA) for Mg^{++} for males is 400 mg/day, hence supplementation does not appear to be necessary when regular meals are eaten. However, Mg^{++} deficiency can occur when there are excessive losses either through the kidneys, sweating, or gastrointestinal tract, or due to inadequate intake (47). Clinical and experimental Mg^{++} deficiency is characterized by hyper-irritability, soft tissue calcification, muscular dysfunction, cardiovascular arrhythmia, tremors, disorientation, ataxic gait, motility problems manifested by dysphagia, and malnutrition (48). Thus, it appears important to avoid Mg^{++} deficiency especially under field conditions.

Severe heat stroke is characterized by hypokalemia and rhabdomyolysis. Maintenance of normal K^+ homeostasis is important for skeletal muscle and gastro-intestinal smooth muscle function (49). Similarly, normal cardiac conduction and function is dependent on maintenance of normal intracellular and extracellular K^+ concentrations. It is especially relevant to avoid K^+ depletion because of the vasopressin resistant hyposthenuria or loss of renal concentrating power associated with K^+ deficiency (48,50). This inability to concentrate urine and to conserve water is crucial under conditions of heat stress.

Phosphorus losses, incurred either in response to heat or secondary to diarrheal losses, should be replaced in view of the pivotal role played by this cation in cell energy production, i.e., adenosine triphosphate (ATP). Other potential clinical problems associated with phosphorus depletion include decreased red blood cell (RBC) 2,3 diphosphoglycerate, and decreased RBC ATP which may impair red cell oxygen release from oxyhemoglobin. Abnormal white blood cell phagocytic, chemotactic, and bactericidal activities have been demonstrated in association with phosphorus depletion as has central nervous system dysfunction characterized by irritability, apprehension, muscular weakness, numbness, dysarthria, confusion, obtundation, seizures, and coma (51). Rhabdomyolysis is associated with phosphorus depletion. Creatine phosphokinase (CPK) elevation, with or without myoglobinuria, has been observed experimentally as well as clinically (51). These observations strongly support the view that phosphorus depletion should be avoided and that phosphorus may need to be supplemented if it is possible that dietary intake may not be adequate.

Troops who are encapsulated in mission oriented protective posture 4 (MOPP4) for 24 hours are fasting because current doctrine only provides for water intake in this configuration. A soldier must find a decontaminated area or shelter before he can remove his mask to eat. Dehydration, hypoglycemia, and ketosis can incapacitate a soldier. A sedentary individual in MOPP4 only requires water for a 24 hour fast. A person who must work at intense levels in a hot environment in MOPP4 could become a heat casualty very quickly and nutrient solutions or water would be ineffective in reducing the rate of this occurrence (52). A soldier working at a moderate workload at a Wet Bulb Globe Temperature (WBGT) of 70°F is subjected to high heat stresses in MOPP4. A nutrient solution might prolong his

ability to work for sustained periods of time. Comparing a 2.5% fructose/maltidextrin solution (NBC solution) to water showed no significant differences in endurance time (17 vs. 16 hours); however, the only subjects that were able to finish the 24 hour test were drinking the nutrient solution (53).

In the event of a war, reservists will be called to duty and must be ready to perform their assigned duties immediately and for a prolonged period of time. Many reservists work in air-conditioned offices and do not exercise extensively. Rapid transition to heavy work in a hot environment presents the very real possibility of extensive dehydration and heat casualties that could incapacitate the unit and make it ineffective. A nutrient solution that could replace fluid and electrolyte losses might reduce personnel incapacitation or performance degradation from heat. Consumption of nutrient solutions may replenish vital body fluids to prevent fatigue and heat injury.

A multipurpose nutrient and electrolyte solution that could be used for troops encapsulated in MOPP4 for 24 hours, for enhancement of fluid intake to prevent heat injury, and for treatment of heat casualties (exhaustion and cramps) could be paramount to the success of military operations. A National Research Council advisory committee recommended a nutrient solution for consumption by encapsulated troops during a chemical/biological attack (NBC Nutrient solution) at a WBGT of 70°F and working at a moderate workload (52). See Appendix A-1 for the NBC Nutrient Solution formulation and chemical analysis. This NBC Nutrient solution may have military value and potential beyond its original purpose such as increasing fluid consumption and replacing lost electrolytes to prevent or treat heat injury in unacclimated soldiers in a hot environment. Another potential use is as an oral replacement fluid for diarrhea. The efficacy of a glucose containing oral rehydration

solution in restoring electrolyte and water deficits in patients suffering from diarrhea is established (54,55). Using the formulation of the NBC Nutrient solution as a foundation, the authors developed a field expedient multipurpose solution called Armyade[1] (Appendix A-2). The electrolyte concentrations were altered by adding Mg^{++} and increasing the amounts of K^{+} and PO_4 to replace potential losses in sweat or diarrhea. At regular dilution Armyade contains the same amount of carbohydrate as the NBC Nutrient solution but the carbohydrate source is entirely in the form of glucose polymers (Malti Dextrin 42) instead of partially from fructose. Several researchers (56,57) have reported gastric upset, epigastric pain, and diarrhea when fructose (20-50 g) is the source of carbohydrate in a nutrient solution. In comparison to glucose, glucose polymers are more rapidly emptied from the stomach, more rapidly absorbed, and immediately available for uptake by the exercising muscle (15,16,60). Glucose polymers also produce a lower osmolality than isocaloric concentrations of glucose. A comparison of the energy, carbohydrate and electrolyte content, and the osmolality of Armyade and NBC Nutrient Solution is shown in Table 1. The sodium and chloride levels in Armyade are the same as in the NBC Nutrient solution, potassium and PO_4 levels are increased and Mg^{++} has been added. Armyade should meet the needs of soldiers in MOPP4 ensemble who are in a fasting state and sweating about 0.5 liter per hour. Although a NBC Nutrient solution is already developed, logistical considerations would dictate consolidating the NBC solution and Armyade into one multipurpose solution. While hyperkalemia, hypermagnesemia, and hyperphosphatemia can result from hemoconcentration from

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1./ Armyade is a descriptive name derived by the authors of this report to describe an experimental multipurpose beverage formulation. The name should not be construed to imply official U.S. Army or Department of Defense endorsement of this product.

Table 1. Comparison of the energy, carbohydrate and electrolyte content, and osmolality of Armyade and NBC Nutrient Solution.

	ELECTROLYTES (mEq/L)								
FLUID	Na^+	Cl^-	K^+	HCO_3	Mg^{++}	PO_4	Carbohydrate (g/L)	Energy (kcal/L)	Osmolality (mOsm/kg)
Armyade	22.8	25.5	9.5	10	5.2	3.2	25	100	127
NBC Nutrient Soln	25.0	24	0.02		0.14	2.0	24.8	99	166

heat injury, these increases are of a modest nature. Clinically significant increases in serum K^+, Mg^{++}, and PO_4 usually occur only in the anuric subject with acute renal failure. Since all soldiers undergo frequent physical examinations and should be in excellent health, pre-existing renal insufficiency is not a widespread condition. Thus, drinking Armyade or NBC solution should not result in hyperkalemia, hypermagnesemia, or hyperphosphatemia. Armyade should be useful not only to soldiers who are in MOPP4 but also to those who are working hard in the heat and who may not consume 3 meals per day due to time constraints, nonavailability of food, and/or anorexia. One packet of Armyade dissolved in a canteen of water would provide sufficient electrolytes to replace sweat losses (Table 2). Treatment of mild heat casualties such as exhaustion or cramps requires hypotonic replacement of fluid and electrolytes (0.1% NaCl). Armyade contains the correct balance of fluids and electrolytes and should be palatable enough to encourage high levels of fluid intake (forced fluids). At double strength (Table 2), Armyade should contain sufficient carbohydrate and electrolytes in the proper balance to serve as an oral rehydrating fluid for treatment of diarrhea in soldiers in the field. The composition of a commercially available carbohydrate-electrolyte beverage (Gatorade ^{R}) is shown in Table 2 for comparison. In summary, the purpose of the Armyade solution is to maintain fluid and electrolyte balance in soldiers encapsulated in MOPP4, enhance fluid intake to prevent heat injuries, treat heat injuries, and to treat diarrhea in the field.

Table 2. Comparison of the electrolyte composition of sweat, diarrhea, and carbohydrate solutions

FLUID	ELECTROLYTES (mEq/L)							
	Na^+	Cl^-	K^+	HCO_3	Mg^{++}	PO_4	Carbohydrate (g/L)	Osmolality (mOsm/kg)
Sweat[1]	40-60	30-50	4-5	0	1.5-5	-	-	
Diarrhea[2]	25-50	20-40	35-60	30-45	8-17[3]	-	-	
Armyade[4]	22.8	25.5	9.5	10	5.2	3.2	25	127
Armyade 2x	45.6	51	19	20	10.4	6.4	50	261
NBC Nutrient	25	24	0.02		0.14	2.0	24.8	166
Gatorade[5]	22.3		2.46			0	43.8	340

[1]Reference 34.

[2]Reference 58.

[3]Reference 59.

[4]Armyade is a descriptive name derived by the authors of this report to describe an experimental multipurpose beverage formulation. The name should not be construed to imply official U.S. Army or Department of Defense endorsement of this product.

[5]Gatorade® is a proprietary trademark of Stokely-Van Camp, Inc., Chicago, IL and is shown here to illustrate the composition of a popular commercial beverage. Hereafter, this product will be referred to as Gatorade.

OBJECTIVES

1. To evaluate fluid intake and voluntary dehydration in a hot field training environment in soldiers who are offered NBC Nutrient solution, Armyade, or a colored-flavored placebo in addition to water and other normally available beverages.

2. To identify and evaluate heat injury in a medical field unit by measuring Total Body Water, Na^+ levels, and blood profiles.

3. To evaluate body weight fluctuations prior to and during desert field exercises.

4. To determine the acceptability of the NBC Nutrient solution compared to water, placebo, and Armyade in the heat.

5. To evaluate the accuracy of satellite-derived estimates of WBGT.

6. To study the relationship between fluid intake and food consumption in prolonged heat exposure.

GENERAL METHODS

The presentation of temperature as degrees Fahrenheit in this technical report is a departure from scientific convention but was done to be consistent with current military doctrine recommendations on heat stress in the field and instrument outputs in the Environmental Heat Stress Section of this report.

Study Population

Volunteers were recruited from reservists of the 44th Evacuation Hospital 807th Medical Brigade participating in a field training exercise (FTX Dusty Bull 1988) at Fort Hood, TX during June 1988. The Reservists were briefed on the purpose of the study in February and March 1988 and signed Volunteer Agreement forms at that time. Prior to the volunteers deploying from their home base, they were assigned to one of 4 beverage groups: Armyade, Control (plain water), a colored-flavored Placebo, and NBC Nutrient Solution (Table 3). However, they were not notified of their group assignments and they were not given any of the test beverages until the day after deployment. To reduce the confounding effects of activity level, age, gender, and work experience, the assignment of volunteers to the different groups was stratified according to military rank, gender, age, and Military Occupational Specialty.

Two subjects did not like the flavor of their pre-assigned test beverage (Armyade and Placebo) and refused to drink their respective test beverages after Day 1. For all intents and purposes, they had assigned themselves to the Control group. Therefore their biochemical, hydration, food, and fluid data were analyzed with that of other soldiers assigned to the Control group.

Table 3. Composition and description of ad libitum fluids consumed by the test groups

GROUP	n	FLUIDS ALLOWED	
ARMYADE	14	TEST BEVERAGE -	Armyade - 2.5% maltidextrin solution with Na^{+}, Mg^{++}, K^{+}, PO_4, Ca^{++}, and HCO_3
		Water	
		Other fluids	
CONTROL	17	TEST BEVERAGE -	water
		Other fluids	
PLACEBO	12	TEST BEVERAGE -	Placebo - colored, flavored, artificially sweetened solution
		Water	
		Other fluids	
NBC	18	TEST BEVERAGE -	NBC Nutrient Solution - 2.5% fructose/maltidextrin soln with Na^{+}, K^{+}, PO_4, Ca^{++}
		Water	
		Other fluids	
TOTAL	61		

However, they rated the acceptability of their test beverages on the final questionnaire, and therefore their demographic and fluid acceptability data were analyzed according to their originally assigned test beverages.

The subjects in each group were allowed to consume their test beverage ad libitum. They were free to choose either water, the test beverage, or other available fluids (soda, juice, koolaid, milk, coffee, tea, etc.). However, the subjects only had one canteen each. They made their own decision as to what they would put into their canteens (test beverage or water) whenever they refilled the canteens. See Appendix A for the formulation and composition of the NBC Nutrient Solution.

Armyade, and Placebo solutions. The packets of Armyade and NBC solution powder were issued to the volunteers two times per day. The Placebo was pre-mixed and available to the soldiers in three thermos jugs placed before the dining tent, heat injury treatment tent, and in the formation area. The test beverages were made from water in the lyster bags and water buffalo. No effort was made to cool the beverages. Water was readily available in 1 water buffalo and 3 lyster bags spread throughout a 0.04 km^2 area for the soldiers to fill their canteens or canteen cups with water. Other available fluids were kept near their cots or in their work area. The data collection sheets showed that some subjects alternated test beverage with water in their canteens, however, others only put test beverage in their canteens.

Sixty-one subjects participated in this study. However, six subjects dropped out of the study after 5 or 6 days and therefore their data could not be used for food and fluid intake analyses (n=55). Three of these subjects had remained in the study for a sufficient period of time that the demographic, biochemical, and final questionnaire data were still valid (n=58). Some subjects dropped out of the study because they had to return to their home station early. Other subjects were dropped out of certain analyses because the data were incomplete. In the hydration section, values were calculated to replace the missing data.

Study Design

Reservists were studied at their home station (Oklahoma City, OK and El Paso, TX) pre-deployment (Day 0 AM); post-deployment (arrival at Fort Hood, TX or Day 0 PM); and during 8 days (Day 1 to 8) of field training. The field training included an Army field training exercise (FTX) named Dusty Bull 88 at Fort Hood, TX. The soldiers erected and lived in tents for the 8 days of the exercise. However, some of

the soldiers attended classes in garrison during the day. On Day 5 of the study, all soldiers including the test subjects were allowed to return to garrison in the afternoon to shop at the PX, take a shower, attend movies, etc. Most of the activities at garrison were conducted in air-conditioned buildings. The subjects kept records of the different foods and fluids that they consumed during this break but urine and body weight data could not be collected for the PM period. The subjects returned to the field by 2200 hours that night.

Two flavored 2.5% carbohydrate-electrolyte solutions, plain water, and a placebo were studied to determine their acceptability and effects. The subjects in the Control group were not given any special test beverage but drank water and any other fluid that they brought to the field *ad libitum* as did the other three groups. The Placebo group was included to determine the effects of the coloring and flavoring components of the test beverages. Measurements of acceptability included a laboratory acceptance test, final questionnaire, quantity of fluid consumed, and daily hedonic ratings of the beverages. See Appendix B for a complete list of the dependent variables. The first carbohydrate-electrolyte solution was the NBC Nutrient solution (NBC solution) which was developed by Natick Labs, on the recommendations of a NRC advisory committee (37) for soldiers encapsulated in MOPP4. The NBC solution was composed of a 2.5% mixture of fructose and maltidextrin, 25.0 mEq/L of Na^+, 24 mEq/L of Cl^-, 0.02 mEq/L of K^+, 0.14 mg of Mg^{++}, 2.0 mEq/L of PO_4, and 11.3 mEq/L of Ca^{++}. The osmolality of the solution was 166 mOsm/kg. To form the Armyade solution, Mg^{++}, PO_4, HCO_3, and K^+ concentrations were added or increased in the NBC solution formula and the fructose was replaced with an equal amount of maltidextrins. The Placebo was colored and flavored as a low calorie (aspartame) lemon-lime drink to match the

appearance and taste of Armyade and the NBC solution. The soldiers were told that we were comparing 3 nutrient-electrolyte solutions to water. Packets for all three solutions were labeled as lemon-lime electrolyte solutions.

The effects of deployment on hydration status were studied by taking body weights and collecting urine from all soldiers on Day 0 AM and Day 0 PM. Body weights and urines were collected two times per day for Days 1 to 8 to examine the effects of the carbohydrate-electrolyte beverages, heat, and light-moderate activity (including periods of more intense physical labor i.e., erecting tents on Day 0 to Day 4) on hydration status. Blood chemistries were obtained on Day 0 PM and Day 8 PM to study the effect of the carbohydrate-electrolyte solutions on serum glucose and electrolytes. Another aspect of the study was to determine the effects of hydration on circulatory system functions. The tilt-test was used to measure orthostatic hypotension on Day 1 and Day 8.

Total body water and rectal temperature data were collected on four test subjects presenting with heat cramp or heat exhaustion. Blood was collected at the time of examination and questionnaires were administered to collect data on the effects of heat illness.

Body Weights

Body weights were taken immediately before deployment (Day 0 AM) and within 2 hours of arrival at the field site, Day 0 PM (Table 4). Measurement of daily weights (AM and PM) began on the morning after the deployment day (Day 1 AM and Day 1 PM) using Seca digital battery operated scales. Weighings were conducted before breakfast and again before dinner. The subjects were weighed in BDU pants, t-shirt, and boots. They were asked to remove their helmet, weapons,

web gear, blouse, and items from their pockets. If all weights could not be obtained on a subject, the mean weight for all other weighings was inserted.

Urine Collection

Urine was collected Day 0 AM in Oklahoma or Texas and Day 0 PM at Fort Hood (Table 4). Starting Day 1 the first urine upon rising (AM) and a late afternoon (PM) urine sample were collected concurrently with body weight measures. The twice daily collections continued for the 8 days (Days 1-8) of field training. Urine samples were analyzed for specific gravity (TS meter) and by dipstick. Aliquots were frozen in liquid nitrogen and transported to the U.S. Army Research Institute of Environmental Medicine (USARIEM) for analyses of Na^{+}, K^{+}, Mg^{++}, and creatinine. If a subject displayed signs of impending dehydration ($\geq$3% body weight loss and/or urine specific gravity $\geq$1.030), he/she was advised to increase his consumption of fluids and food. Urine samples were not available from all subjects at all collections; therefore the mean of the reading from the day before and the day after that missing value was calculated and used for data analysis. AM urine values were used to calculate AM values, and likewise, PM values were used to calculate the missing PM data. This procedure was used to replace missing values because only 5% of the urine samples were missing and the computer programs could not handle missing data. When reporting the incidence data, only available data were used.

Table 4. Testing for all subjects (no heat casualties).

TIME	WEIGHT AM & PM	URINE [1](AM void) [2](PM void)	ACCEPTA-BILITY	FOOD INTAKE (B & D)	24h FLUID INTAKE AM & PM	ORTHOSTATIC HYPOTENSION	BLOOD
Pre-Deploy (Day 0 AM)	1x	1x					
Post-Deploy (Day 0 PM)	1x	1x					1x
Day 1	2x	2x	1x	2x	2x	1x	
Day 2	2x	2x	1x	2x	2x		
Day 3	2x	2x	1x	2x	2x		
Day 4	2x	2x	1x	2x	2x		
Day 5	2x	2x	1x	2x	2x		
Day 6	2x	2x	1x	2x	2x		
Day 7	2x	2x	1x	2x	2x		
Day 8	2x	2x	1x	2x	2x	1x	1x
Day 9			Questionnaire				

[1]First morning void

[2]Void at end of work shift before dinner meal

Blood Collection

Blood was collected from most of the volunteers twice during the test period. The first sample was taken within 2 hours of arrival at Fort Hood (Day 0 PM), and the second during the Day 8 PM body weight and urine collection. The blood was centrifuged, the serum frozen in dry ice, and the samples sent to Wishard Memorial Hospital, Indianapolis, IN for analysis. The serum samples were analyzed to obtain serum glucose, sodium, potassium, creatinine, cholesterol, albumin, total protein, triglyceride, chloride, blood urea nitrogen, magnesium, and phosphorus. The Kodak Ektachem 700 blood analyzer was used to measure blood chemistries on the serum samples. The Dupont ACA 3 was used to determine serum magnesium and triglyceride levels.

Fluid Temperature

Several investigators have reported that fluid temperature affects the acceptability of a beverage (13,61-63), and therefore, the water temperatures were measured. The water in the water buffalo, mess hall lyster bag, and heat tent lyster bag were tested from Days 4-7. The pre-mixed Placebo fluids in the thermos jugs were tested at the same time. Fluid temperatures averaged about 75.1°F for the water and about 79.4°F for the Placebo solution. In general the Placebo fluids were warmer than the water because the lyster bags and water buffalo maintained cooler temperatures due to wet bulb effects and the large water mass.

Statistics

The data were analyzed using the BMDP 2V program to test for sphericity and the 4V program for a multivariate ANOVA with repeated measures. The analyses

were run to test for differences between the 4 beverage groups and for repeated measures differences over the 8 days. If significant differences were found, then Tukey's HSD post hoc tests were run to determine which groups were different. If other statistical tests were used, the information was included in the methods sections of the specific section. The data are reported as mean and standard error of the mean (mean±SEM).

DEMOGRAPHIC DATA

Physical characteristics of subjects participating in this study are listed in Table 5. The weight that was used for this table is the pre-deployment (Day 0 AM) weight taken at their home station (Oklahoma City, OK or El Paso, TX) before the soldiers were transported to Fort Hood, TX. Some data were missing on height because the soldiers were unsure of their exact height or did not fill out the final questionnaire.

Table 5. Physical characteristics of subjects.

VARIABLE	NUMBER	MEAN±SEM	MINIMUM	MAXIMUM
Age, years	61	33.6±1.1	19	51
Height, cm*	51	173.5±1.5	152.4	198.1
Weight, kg	61	75.4±2.0	41.5	128.2

*Pre-deployment or Day 0 AM weight

The demographic data were collected on the morning of Day 9 as part of the final questionnaire. Fifty-eight of the 61 subjects completed the final questionnaire. Descriptive statistics were obtained using the Statistical Package for the Social Sciences (SPSSx). Table 6 displays the demographic information collected from subjects in each of the four groups. Inspection of the entries in this table reveals considerable similarity in subject characteristics across groups in terms of age, height, weight, sex, years of service, and distribution of ranks. In each of the groups, approximately half of the subjects were between the ages of 18 and 34 years and approximately half of the subjects were age 35 years or older. Males and females

DEMOGRAPHIC DATA

Table 6. Demographic information of subjects consuming water, a flavored water placebo, or two nutrient solutions.

	GROUPS			
	CONTROL (n=14)	PLACEBO (n=12)	ARMYADE (n=15)	NBC (n=17)
AGE (years) (%)				
under 18	0	0	0	0
18 - 24	21.4	8.3	6.7	17.6
25 - 34	21.4	33.3	40.7	35.3
35 - 44	57.1	41.7	46.7	35.3
45 - 54	0	16.7	6.7	11.8
55 or older	0	0	0	0
HEIGHT (inches)[a]	69.7 (1.3)	68.6 (1.2)	66.1 (0.7)	69.0 (1.0)
WEIGHT (pounds)[a]	165.6 (10.1)	151 (6.1)	145.7 (7.6)	160.5 (7.8)
SEX (%)				
Male	50	55	47	59
Female 50	45	53	41	
YEARS OF SERVICE (%)				
0 - 5	50	41.7	33.3	52.9
6 - 10	21.4	16.7	33.3	17.6
11 - 15	21.4	8.3	13.3	5.6
16 - 20	7.1	8.3	13.3	23.9
more than 20	0	25.0	6.7	0
POINT OF ORIGIN (%)				
El Paso, TX	36	33	53	24
Oklahoma City, OK	64	67	47	71
Other	0	0	0	5

Table 6. (Continued)

	CONTROL (n=14)	PLACEBO (n=12)	ARMYADE (n=15)	NBC (n=17)
	GROUPS			
DISTRIBUTION OF RANKS (%)				
ENLISTED				
E-1	0	0	0	0
E-2	14.3	0	0	0
E-3	7.1	16.7	13.3	5.9
E-4	7.1	8.3	0	17.6
E-5	7.1	16.7	26.7	17.6
E-6	7.1	0	6.7	0
E-7	0	8.3	0	0
OFFICERS				
0-1	14.3	16.7	20.0	23.5
0-2	7.1	0	6.7	0
0-3	21.4	8.3	6.7	11.8
0-4	14.3	0	13.3	11.8
0-5	0	16.7	6.7	11.8
WARRANT OFFICER				
WO-1	0	0	0	0
WO-2	0	8.3	0	0
EXPERIENCE LIVING/WORKING IN A HOT CLIMATE (%)				
No experience	0	8.3	0	0
Slightly experienced	28.6	25.0	13.3	23.5
Moderately experienced	21.4	25.0	33.3	17.6
Very experienced	50.0	41.7	53.3	58.8
TRYING TO LOSE WEIGHT (%)	23.0	17.0	40.0	24.0
TRYING TO GAIN WEIGHT (%)	0	0	7	0

Note. With the exception of height and weight. all entries in this table are in terms of the percentage of subjects that responded to the question.

[a] The mean height and weight of subjects responding with standard errors given in parentheses.

were evenly distributed across groups with approximately 50% of each sex in each group. With the exception of subjects in the Armyade group, the highest percentage of subjects in each of the categories for years of service fell into the 0-5 year category. One third of the subjects in the Armyade group had been in the service for 0-5 years while another third had been in the service for 6-10 years. In each of the four groups, 40-50% of the subjects were enlisted personnel and the remaining 50-60% were officers.

Table 6 shows that the four groups were also similar in terms of the amount of previous experience that subjects had working/living in a hot climate. The subjects were living in El Paso, TX or Oklahoma City, OK, but they were separated into each of the four groups. A very low percentage of subjects indicated having no experience in a hot climate while approximately half of the subjects in each group described themselves as very experienced. No consistent relationship was detected between the amount of experience an individual reported and the individual's report of having had heat-related injuries in the past. The absence of a clear relationship here may be due to the subjects' inability to recognize the symptoms of heat exhaustion, dehydration, heat stroke, and heat cramps. Even while experiencing these injuries (identified by high specific gravities, symptoms, and positive tilt test; see Hydration Section) during the field test, many subjects may have been unaware of their problems.

Subjects also were asked whether they were trying to lose weight. Averaged across groups, 26% of the subjects answered this question affirmatively. While the existence of cells with expected frequencies less

than five did not permit use of a Chi Square analysis to examine between group differences, the 26% overall compares well with the frequency of reported dieting noted in other studies (64).

EFFECTS OF DEPLOYMENT

METHODS

Body weights were taken about 2 hrs before the soldiers embarked (Day 0 AM) from their home station (El Paso, TX or Oklahoma City, OK) and within 2 hrs of arrival at the Fort Hood field site (Day 0 PM). Body weight was obtained while each subject was dressed in BDU trousers, t-shirt, socks, boots, and undergarments. Sequential weights were taken identically before meals in the morning (AM) and afternoon (PM) for the next eight days (Days 1-8) after deployment. A body weight loss of $\geq$3% from pre-deployment weight and/or a urinary specific gravity of $\geq$1.030 were used as indices of impending hypohydration.

Pre-labeled urine containers (about 50 ml capacity) were provided to each subject at each collection and weigh-in for the next collection period. Individuals were instructed to collect about 25 ml of urine. Urine was collected pre- and post-deployment. Beginning on the morning of DAY 1, the first void urine (AM) and an afternoon sample (PM) were collected concurrently with body weight measures. Urine collections were made for the next seven days of the field exercise.

An aliquot of the fresh urine was assayed for specific gravity by refractometry in a field chemistry lab. Another aliquot was taken and frozen in liquid nitrogen for analysis of sodium, potassium, creatinine, and magnesium at USARIEM, Natick, MA. If urinary specific gravity was $\geq$1.030 and/or body weight loss was $\geq$3% of pre-deployment weight, individuals were encouraged to consume fluids and food. The test beverages were not available for consumption during deployment. During the analysis of the deployment data the subjects were categorized according to the study test groups to ensure that no group started the study significantly different from the other groups.

EFFECTS OF DEPLOYMENT

Calculated values were generated from a subject's AM or PM values (for AM or PM values, respectively) when a urine sample or body weight measurement was unavailable. However, these calculated values were not used when generating frequency distributions. A chi-square was computed to establish the relationship between incidence of urine specific gravity $\geq$1.030 and groups.

RESULTS AND DISCUSSION

In an earlier study (64), about 15% of the troops lost more than 3% body weight when transportation comprised airflight and ground movement. In these same troops, a very high incidence (40-60%) of concentrated urines occurred following deployment.

In the present study, troops deployed by chartered bus from El Paso, Texas at about 0230 hrs and arrived at the field testing site at Fort Hood, Texas around 1900 hrs. Deployment from Oklahoma City, Oklahoma to Fort Hood occurred between 0600 and 1630 hrs of the same day. Because frequent stops for food and beverages were made, and deployment occurred in less than one day, absence of acute dehydration in many of the troops was not surprising.

Subjects were randomly assigned to the four groups prior to initial data collection. By chance, the heaviest individuals were assigned to the Control, Placebo, and NBC groups in which ranges of body weight were 53-128 kg, 55.5-107 kg, and 42-118 kg, respectively. In contrast, the heaviest individual in the Armyade group weighed only 92 kg. However, differences in average pre-deployment body weights were not statistically significant among groups. In fact, random differences in mean body weights can be tolerated because responses were unrelated to the pre-deployment body weight. Body weight changes and urine specific gravity obtained within two hours prior to deployment (PRE) and about two hours after arrival at the test site at Fort Hood (POST) were used to evaluate the effects of deployment on hydration status. Urinary specific gravity $\geq$1.030 was used as an initial criterion for hypohydration.

Average urine specific gravity for each group is presented in Table 7. None of the groups had an average urine specific gravity that exceeded 1.030 prior to or

following deployment. Only the individuals assigned to the Control group had a statistically higher urine specific gravity ($p<0.05$) post-deployment, but the physiological importance of this increment is minimal since the average values were well within the normal range (1.002-1.030) expected for a random sampling (65).

Table 7. Effect of deployment on urinary specific gravity.

	GROUPS				
	ARMYADE	CONTROL	PLACEBO	NBC	MEAN
PRE DEPLOYMENT	1.021 ±0.002	1.020 ±0.002	1.019 ±0.002	1.022 ±0.002	1.020 ±0.001
POST DEPLOYMENT	1.020 ±0.002	1.023* ±0.002	1.020 ±0.002	1.019 ±0.002	1.021 ±0.001
NUMBER OF SUBJECTS	(14)	(17)	(12)	(18)	(61)

Values are mean±1SEM.

* Indicates significant difference ($p<0.05$) between pre- and post-deployment.

No statistical differences were noted in urine specific gravity among the four groups either pre- or post-deployment. For this reason, the values from all four groups were combined and their observed incidences were plotted as frequency histograms in Figure 1 for both pre- and post-deployment. These data show a similar distribution and average value for urinary specific gravity, pre and post-deployment. These frequency distributions indicate that hydration varies quite remarkably between individuals even when activity is limited, and also that not all individuals were optimally hydrated. Four subjects (8%) pre-deployment and

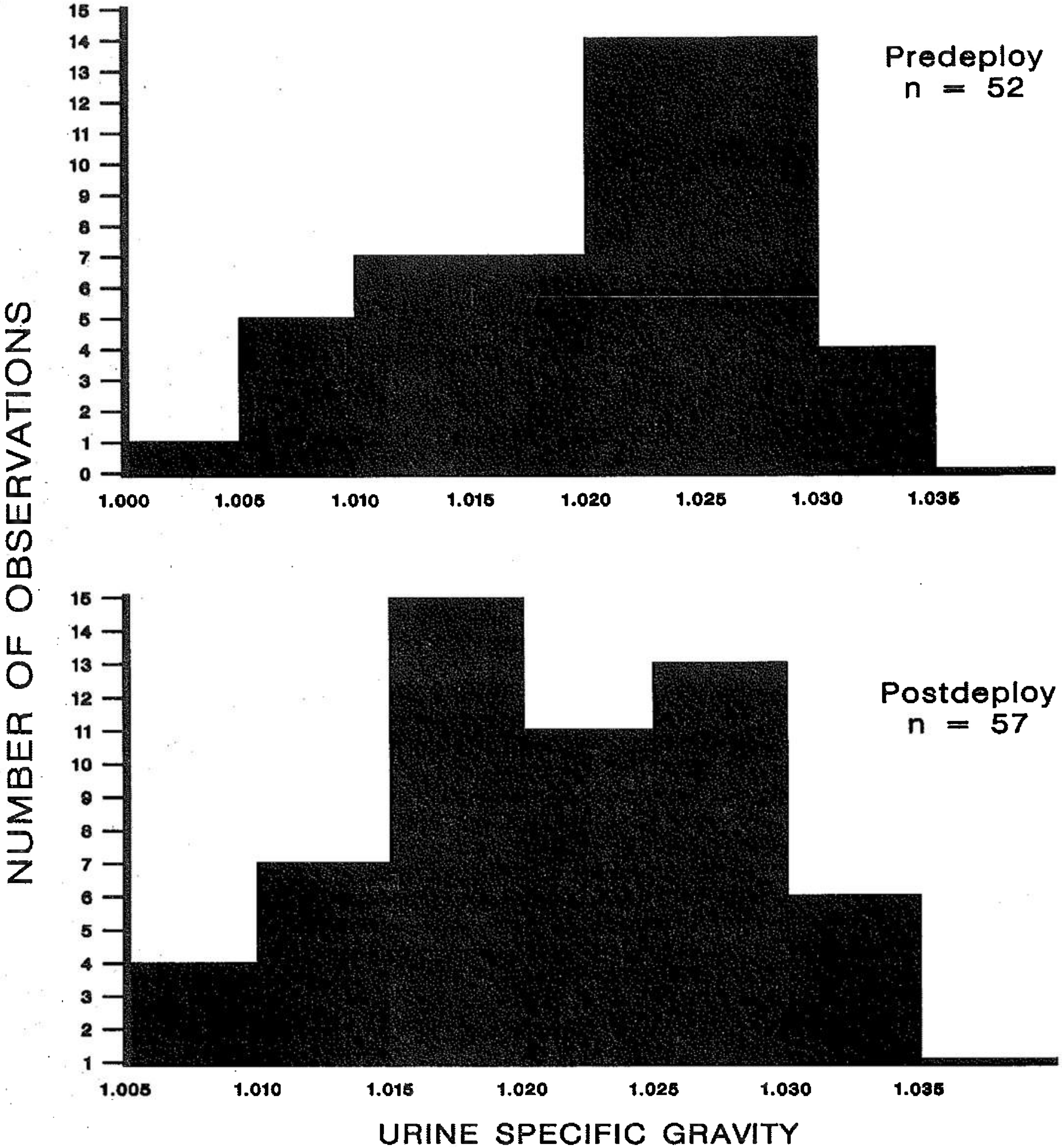

Figure 1. Urine specific gravity pre- and post- deployment

six subjects (11%) post-deployment had concentrated urines with specific gravities exceeding our criteria for impending hypohydration. These data support the finding that soldiers riding all day in tanks or trucks do not rehydrate as well as men sitting in the shade and drinking voluntarily (66).

The frequency distribution (Figure 2) of body weight changes for all soldiers demonstrates the variability in change of body weight (range= -2.75 to 2.15%) during the deployment phase. The second criterion of hypohydration was loss of $\geq$3% of pre-deployment body weight. Table 8 shows the mean body weights for all four groups before and after deployment as well as the percent body weight lost during the deployment. The average body weight data also confirm that acute dehydration did not occur in any group during deployment. None of the differences in body weight were physiologically significant and no group had a weight loss $\geq$3% during the deployment.

Normal values for creatinine ordinarily range between 0.8 g/dl and 2.0 g/dl in 24 hour urine collections, whereas urinary sodium and potassium values are correlated with dietary intake (65). Table 9 shows the values obtained for sodium and potassium during the deployment day. While there were no significant differences between pre- and post-deployment values for subjects assigned to (but not consuming during deployment) the Armyade and NBC solution groups, the subjects assigned to (but not consuming during deployment) the Control and Placebo groups showed an increase in sodium (and for the Control group an increase also in urinary potassium) that resulted in corresponding significant decreases in urine sodium to potassium ratios pre- to post-deployment. Decrements

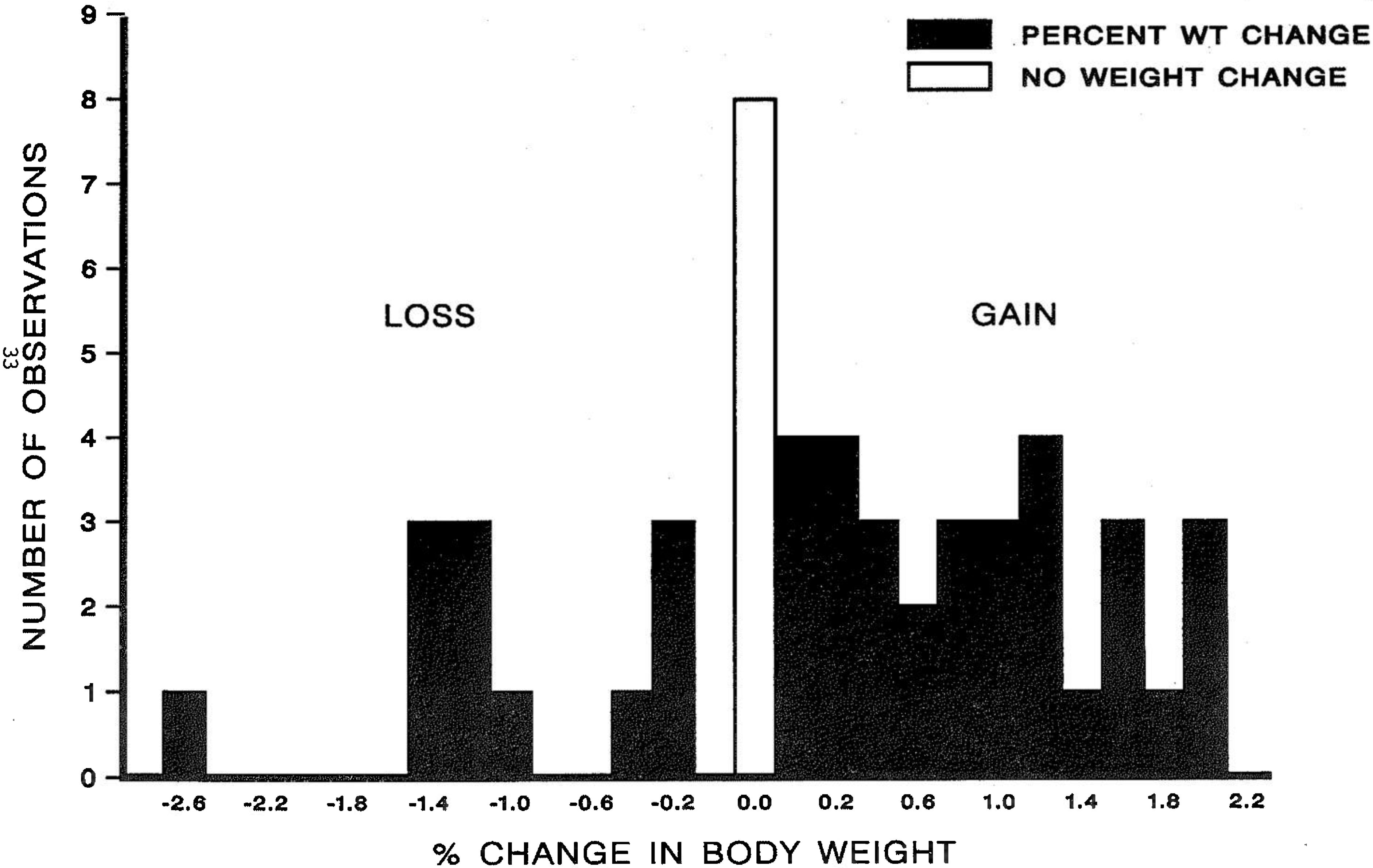

Figure 2. Percent change in body weight during deployment

Table 8. Effect of deployment on body weight (kg).

	GROUPS				
	ARMYADE	CONTROL	PLACEBO	NBC	MEAN
PRE DEPLOYMENT	68.4 ±3.1	78.4 ±4.2	74.9 ±4.2	78.5 ±3.7	75.4 ±2.0
POST DEPLOYMENT	68.6 ±3.1	78.5 ±4.2	75.0 ±4.1	78.9* ±3.7	75.6 ±2.0
% CHANGE IN BODY WEIGHT FROM PRE	0.3 ±0.2	0.1 ±0.2	0.2 ±0.3	0.5 ±0.3	0.3 ±0.1
NUMBER OF SUBJECTS	14	17	12	18	61

Values are mean±1SEM.

* Indicates significant difference ($p<0.05$) between pre- and post- deployment.

Table 9. Effect of deployment on urinary sodium and potassium (mEq/L).

	GROUP				
	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)	MEAN (n=61
SODIUM (Na^+)					
PRE-DEPLOYMENT	152 ±14	121 ±18	127 ±14	130 ±15	132 ± 8
POST-DEPLOYMENT	139 ±18	147* ±16	152* ±16	130 ±14	141 ± 8
POTASSIUM (K^+)					
PRE-DEPLOYMENT	46.0 ±7.4	43.5 ±6.7	35.5 ±5.8	48.4 ±7.0	43.9 ±3.4
POST-DEPLOYMENT	40.0 ±5.2	66.9* ±7.3	48.2 ±5.0	56.8 ±8.0	54.0* ±3.6
Na^+/K^+ RATIO					
PRE-DEPLOYMENT	4.14 ±0.60	3.78 ±0.59	4.23 ±0.64	3.53 ±0.61	3.88 ±0.30
POST-DEPLOYMENT	3.58 ±0.32	2.48* ±0.44	3.31* ±0.53	2.97 ±0.33	3.04* ±0.20

Values indicated are mean±1SEM.

* Indicates significant difference ($p<0.05$) from pre-deployment.

in sodium to potassium ratios may be indicative of developing hypohydration as Na^+ becomes conserved (67). Since none of the groups consumed their assigned test beverage during deployment, the increased urinary sodium most probably reflected the increased salt intake from frequent food stops enroute to the deployment site.

Table 10 shows that urinary creatinine concentrations were generally consistent among groups and from pre- to post-deployment.

Table 10. Effect of deployment on urinary creatinine (g/dl).

	GROUP				
	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)	MEAN (n=61)
PRE-DEPLOYMENT	0.19 ±0.02	0.18 ±0.03	0.16 ±0.03	0.18 ±0.02	0.18 ±0.01
POST-DEPLOYMENT	0.17 ±0.03	0.20 ±0.03	0.17 ±0.02	0.18 ±0.03	0.18 ±0.01

Values are mean±1SEM.

The majority of the 61 subjects lived and worked in Oklahoma City, OK. The soldiers from El Paso, TX were distributed among the four different test groups so as not to bias the data due to area of residence. The only significant difference in hydration indices based upon the point of origin (Table 11) was the significantly higher ($p<0.05$) urinary potassium for the post-deployment sample for the El Paso, TX group compared to the Oklahoma City, OK group. This high level may reflect losses due to more frequent food stops, the longer distance deployed, and perhaps

Table 11. Effects of point of origin on urine indices of hydration during deployment.

HYDRATION INDICES	POINT OF ORIGIN			
	EL PASO, TX		OKLAHOMA CITY, OK	
	AM (n=21)	PM (n=21)	AM (n=40)	PM (n=40)
Body Weight (kg)	75.5±3.3	75.4±3.3	75.4±2.5	75.8±2.5
Urine Specific Gravity	1.021±0.002	1.023±0.001	1.020±0.001	1.019±0.001
Urinary Na^+ (mEq/L)	142±15	154±15	127±9	134±9
Urinary K^+ (mEq/L)	51.5±7.4	66.4±7.0	39.9±3.3	47.5±3.9*
Urinary Na^+/K^+	3.88±0.52	2.91±0.45	3.87±0.38	3.43±0.34
Urinary Creatinine (g/dl)	0.18±0.02	0.18±0.02	0.17±0.01	0.18±0.02

Values are mean±1SEM.

*Indicates significant differences ($p<0.05$) between points of origin.

greater hypohydration during deployment compared to the Oklahoma group. No significant differences were noted between pre- and post-deployment in either group.

CONCLUSIONS

In general, fluid and food consumption during the day of deployment was sufficient to maintain body weight and adequate hydration in most troops.

ENVIRONMENTAL HEAT STRESS LEVELS

METHODS

Prevailing heat stress levels, measured in terms of Wet Bulb Globe Temperature (WBGT) index, were monitored throughout the test period 6-13 June 1988. WBGT measurements, using the standard WBGT apparatus (68), and sling psychrometer readings were taken at half hour intervals during the daylight hours. Instantaneous and average windspeed and relative humidity were continuously recorded using a battery operated portable weather station (Met Set 4B, MET ONE, Inc.).

WBGT measurements also were made by 44th Medical Evacuation personnel using the WBGT Kit (NSN 6665-00-159-2218). These readings were disseminated to local units through the communications network.

Additional WBGT measurements were taken to more rigorously document the temporal (minute-to-minute) and spatial (place-to-place) variation in the level of heat stress experienced by the soldiers across time as they moved about within the training area. An array of 7 electronic WBGT data loggers (hs-371, Metrosonics Inc.) was deployed within a 1 km^2 section of the training area which included the hospital location. Time indexed WBGT data from the 7 data loggers were obtained at 1 minute intervals.

Area WBGT assessments were made using data obtained from National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites and remote-sensing methods currently under development by USAMRDC (SBIR Contract No. DAMD-17-86-C-6004, Gulf Weather Corporation, Bay Saint Louis, MS).

To present the results in a form that is familiar to those having field experience with military heat stress measurements and to be consistent with current doctrine specifications and instrument outputs, degrees Fahrenheit and quarts per hour were used as units of measure on charts in this section.

RESULTS AND DISCUSSION

Heat Stress Conditions During the Test Period.

Table 12 shows maximum Dry Bulb and WBGT temperatures, and sky and wind conditions for each of the test days.

Table 12. Maximum dry bulb and WBGT temperatures and sky and wind conditions[a].

Day	Max Dry Bulb (°F)	Max WBGT (°F)	Sky	Wind (mph)
1	91.4	83.3	pt. cloudy	1-5
2	94.1	85.9	pt. cloudy	1-10
3	97.0	85.7	clear	5-15
4	101.0	90.3	clear	3-10
5	87.9	79.3	clear	3-15
6	87.6	79.4	clear	1-7
7	89.5	78.5	clear	2-15
8	88.4	82.3	pt. cloudy	1-12

[a]As measured by standard WBGT apparatus described in Reference 68 within 0.5 km radius of the hospital tents.

Appendix C, shows daily WBGT profiles in relation to doctrine-based water consumption guidelines and work/rest cycle limits (69,70).

The most severe environmental heat stress occurred on day 4, when WBGT values exceeded the 82°F threshold for more than 9 hours (1000 hrs - 1930 hrs), and the maximum WBGT for the day reached 90.3°F. From day 5 through day 8 the daily maximum WBGT remained below 82.3°F. With the exception of days 2 to 4, the test period would have to be characterized as one of low environmental heat stress and below the normal temperatures expected for Fort Hood, TX in the month of June.

Spatial and Temporal Uniformity of the Heat Stress Environment.

Although the half-hourly standard WBGT readings were taken approximately 50 meters away from the nearest tents to minimize wind shadow effects, it is clear from the WBGT profiles that the passing clouds and windspeed fluctuations had a striking effect on the WBGT profiles for days 1,2, and 8. Since doctrine-based guidelines are issued on the basis of a single WBGT measurement, made typically on the hour or half hour, it is worthwhile to examine how well a single, discrete WBGT reading represents conditions during the next measurement interval, and also, how well it represents conditions some distance from the measurement site.

Table 13 illustrates the temporal and spatial variation associated with the 1430 hrs reading on day 2 using 1 minute interval data from the Metrosonics WBGT meters.

Table 13. Temporal and spatial variation of the WBGT environment, Day 2.

	VARIATION		
	TEMPORAL*	SPATIAL**	TOTAL***
N:	30	7	210
Range:	78.5-83.7	78.4-83.7	77.5-84.7
Mean:	79.9	81.7	79.9
SD:	±1.5	±1.8	±1.6

* 1 minute interval readings, 1430-1459, central site.

** 1430 reading at central and six outlying sites.

*** 1 minute interval readings, 1430-1459, at central and six outlying sites.

The standard WBGT apparatus at the central site provided a reading of 84.5°F at 1430. (The co-located electronic WBGT logger was reading 83.7°F at that time.) In

comparison to the spatially and temporally averaged WBGT logger values for the 1 km^2 area over the next 29 minutes, the standard half-hourly reading misrepresented average conditions, in this case, by approximately 4°F. Since a single point measure of WBGT every half hour per km^2 of troop activity probably represents a practical limit for environmental monitoring at the unit level, other approaches to augment or improve point-measurement capabilities in operational settings merit consideration.

Satellite Remote Sensing of the Heat Stress Environment

Table 14 shows a comparison of the satellite-derived WBGT with the nearest minute WBGT measurements from the loggers.

Table 14. Comparison of satellite-derived WBGT with contemporary surface level measurements.

DAY	TIME	SATELLITE/ORBIT#	SATELLITE WBGT	MEASURED WBGT	DIFFERENCE
0	9:04	NOAA 10/8913	75.4°F	68.8°F	6.6°F
1	8:42	NOAA 10/8927	70.9	69.4	1.5
2	17:27	NOAA 9/17965	80.1	82.5	-2.4
3	9:39	NOAA 10/8956	75.8	75.1	0.7
	17:16	NOAA 9/17979	81.1	84.9	-3.8
4	9:17	NOAA 10/8970	78.9	79.5	-0.6
	17:05	NOAA 9/17993	81.6	85.7	-4.1
	20:34	NOAA 10/8977	75.2	78.2	-3.0
5	16:54	NOAA 9/18007	74.9	78.6	-3.7
6	16:42	NOAA 9/18021	73.1	77.4	-4.3
7	16:31	NOAA 9/18035	68.0	73.1	-5.1

For the eleven satellite passes in Table 14, the average difference between the satellite-derived and surface WBGT measurements was -1.8°F (too low) and the

standard deviation around that bias was ±3.7^{o}F. Work is in progress to identify those satellite-derived WBGT components responsible for the generally low estimates of WBGT at Fort Hood, and the necessary adjustments will be made to the respective algorithms. Nevertheless, in the context of the inherent uncertainty in the 'ground truth' measurements themselves (spatial variation ±1.8^{o}F, logger accuracy specification ±0.9^{o}F) these results are remarkably good. We conclude that the satellite remote sensing methods currently being developed under the SBIR contract with Gulf Weather Corporation performed very well at Fort Hood. The full development of this methodology will offer dramatic improvements over existing capabilities for heat stress assessments in training or operational settings.

INCIDENCE OF HEAT ILLNESS

METHOD

Four cases of mild heat exhaustion and heat cramps were studied. Heat stroke patients (requiring evacuation) did not exist and were not studied. Rectal temperatures, symptoms, and neurological status were obtained as soon as each subject appeared at the air-conditioned treatment tent (Table 15) according to a pre-determined protocol. All heat exhaustion and heat cramp patients had 2 blood samples drawn to determine Na^{+} depletion and total body water (TBW) via stable isotope dilution procedures. A 16 ml sample of blood was drawn, the subject was asked to drink 100 ml of a deuteurated water (D_2O) dose, and an additional 16 ml sample of blood was drawn 2 hours post-dose. In addition to the D_2O measurement, the first blood sample was analyzed for total protein, hematocrit, BUN, Na^{+}, K^{+}, Cl^{-}, Mg^{++}, Ca^{++}, osmolality, creatinine, CPK, LDH, SGOT, and SGPT. Total body water also was measured by pre- and post-dose urine and saliva collections. Twenty-four hour urine samples were collected from all heat injury patients. Each subject was asked to complete 6 questionnaires during recovery. These questionnaires requested data on health history (life); personal characteristics (height, weight, age, PT test score); exercise history; heat exposure history (30 days); environmental symptoms; and pre-disposing factors. After the field exercise ended, all heat casualties were contacted by mail, with follow-up questions.

Table 15. Protocol for evaluation of mild heat exhaustion & heat cramps casualties - each event

TIME	RECTAL TEMP	BODY WEIGHT	24-hr URINE	QUESTIONNAIRES	TBW[1] (32 ml blood)
Casualty Day	ASAP+3X	1X	1x	1x	ASAP
C+24 h	2X	1x		1x	
C+48 h	2X				
Post-FTX				1x[2]	

C = Day became casualty

ASAP= As soon as subject was stabilized and was free to talk.

[1]Maximum of 2 times in 8 days

[2]Examined medical records

RESULTS and DISCUSSION

Specific results regarding the total body water and blood chemistry values of the four heat exhaustion patients will appear in a separate technical report. However, records of heat illness admissions were maintained during the study plus one extra day; these appear in Table 16. The heat injuries consisted mainly of soldiers from units other than the 44th Evacuation Hospital (i.e., other units of the 807th Medical Brigade and tank units in the area) who were transported to the 44th Evacuation Hospital for treatment. This occurred because the 44th Evacuation Hospital served as a triage point for all heat illness (except heat stroke) during the FTX Dusty Bull 88. The heat illness admissions to the 44th Evacuation Hospital heat treatment tent were categorized as either (a) heat cramps, (b) non-specific heat effects, (c) mild heat exhaustion/dehydration, (d) heat exhaustion, or (e) heat syncope. The obviously high incidence of heat illness on Day 4 coincides with the high dry bulb and WBGT values recorded on that day (maximum dry bulb 101^{o}F, category IV, maximum WBGT 90.3^{o}F). Progressive dehydration and fatigue may have played a role in the large number of admissions on Day 4; however, they did not alter the number of admissions on Days 5-9.

A total complement of 268 Reservists of the 44th Evacuation Hospital reported to Fort Hood. Some of these reservists are included in Table 16 but additional data from the entire period of the FTX indicated that ten soldiers were treated for heat illness (3.6%). Three of the sixty-one subjects participating in the study were admitted for mild dehydration and seven of the 207 non-study soldiers were admitted for mild to moderate dehydration. The three study subjects were assigned to three different study groups, therefore there was no relationship between test beverages and the incidence of hospital admissions for mild dehydration.

Table 16. Heat illness admissions at the 44th Evacuation Hospital.

DAY	HEAT CRAMPS	NON-SPECIFIC HEAT EFFECTS	MILD HEAT EXHAUSTION/ DEHYDRATION	HEAT EXHAUSTION	HEAT SYNCOPE
1					
2		1		1*+	
3					1
4		5	5	3*	
5					
6			1		1
7					
8					
9					
Total	0	6	6	4	2

* - full measurements (blood, total body water) attempted

+ - including heat cramps

FLUID CONSUMPTION

METHODS

One of the purposes of this study was to test the acceptability of the test beverages by allowing the subjects free choice on the types and amounts of fluids that they could consume. The subjects in all four test groups were allowed to consume water and other fluids ad libitum. The Control group used plain water as its test beverage whereas the other three groups were given Armyade, the NBC solution or a Placebo to drink ad libitum in addition to water and other available fluids.

To determine if the test beverages were encouraging fluid intake, the soldiers were given fluid intake cards to record the number of canteens of each fluid (water and test beverage) consumed. The subjects were asked to record all other fluids that they consumed between meals (e.g., soda, tea, koolaid, etc.) on these cards. Because the data are not 100% complete, means were calculated and used to replace missing values for the data analysis of daily total fluid consumption only (Table 17). Approximately 2% of the 1705 data collection forms for total fluid intake data were missing values. Data were collected from: a) breakfast meals served by food service personnel; b) dinner meals served by food service personnel (dinner changed to lunch on day 5); c) self-reported forms at 0530 hours that covered the period from 1630 hr of the previous day to 0530 hours (PM card); and d) self-reported forms at 1630 hours (AM card) that covered the period from 0530 hours that morning to 1630 hours (except Day 5 when the data from the AM and PM cards were combined and collected at 0530 hours on Day 6). The procedure of using calculated means to replace missing data was not possible for other analyses (e.g., energy intake, sodium intake, etc.), and therefore the values in Table 17 do not exactly match other tables. The cards were issued and collected at the AM and

PM weighings. Information on fluid intake at the two hot meals served by Food Service were collected by the nutrition data collectors. Information on fluid intakes during the lunch period were recorded on the fluid intake cards. A rating scale was included on the fluid intake card so the soldiers could rate the acceptability of the solutions daily (Appendix D).

RESULTS AND DISCUSSION

Daily Total Fluid Consumption

The mean intake of fluid was 4672±104 ml/day with individual intakes ranging from a minimum of 705 ml on Day 5 for one subject in the Armyade group to a maximum of 13,770 ml on Day 4 for a subject in the Control group. On each of the eight days the subjects in the NBC group consumed the most fluid with a mean intake of 5241±195 ml/day while the subjects drinking Armyade consistently tended to consume the least at 4097±185 ml/day. During the Bright Star field exercises (71), subjects consumed about 1344-4224 ml of plain water from their canteens in the 8 hour period that covered the hottest part of the day. The units were participating in desert field exercises where the WBGT ranged from 81.0-86.0^{o}F as in the present study. The mean intake for a 24-hour time period in the present study was similar to the water intakes during a shorter 8-hour period for the medical, engineer, and Marine units that were engaged in light activity.

A one way analysis of variance of total daily fluid consumption for each man-day (440 man-days in 4 groups) showed significant differences ($p<0.001$) between groups (Table 17 and Figure 3). Essentially, the subjects in the NBC group consumed signficantly greater amounts of fluid than those in the Armyade group. This difference in fluid intake is clearly related to similar differences in daily hedonic ratings and in hydration status. Briefly, the NBC solution had a significantly higher hedonic rating and a lower incidence of hypohydration as measured by specific gravity $\geq$ 1.030 than the Armyade group (See Hydration Status section).

A repeated measures analysis of variance by group and across days showed a clear day effect ($F(7,45)==5.69$, $p<0.001$), no strong group differences ($F(3,51)=0.95$, $p=0.42$), and no evidence of a group by day effect. See Table 17

Figure 3. Total fluid intake divided into water, colored flavored test beverage (CFTB), and other fluids.

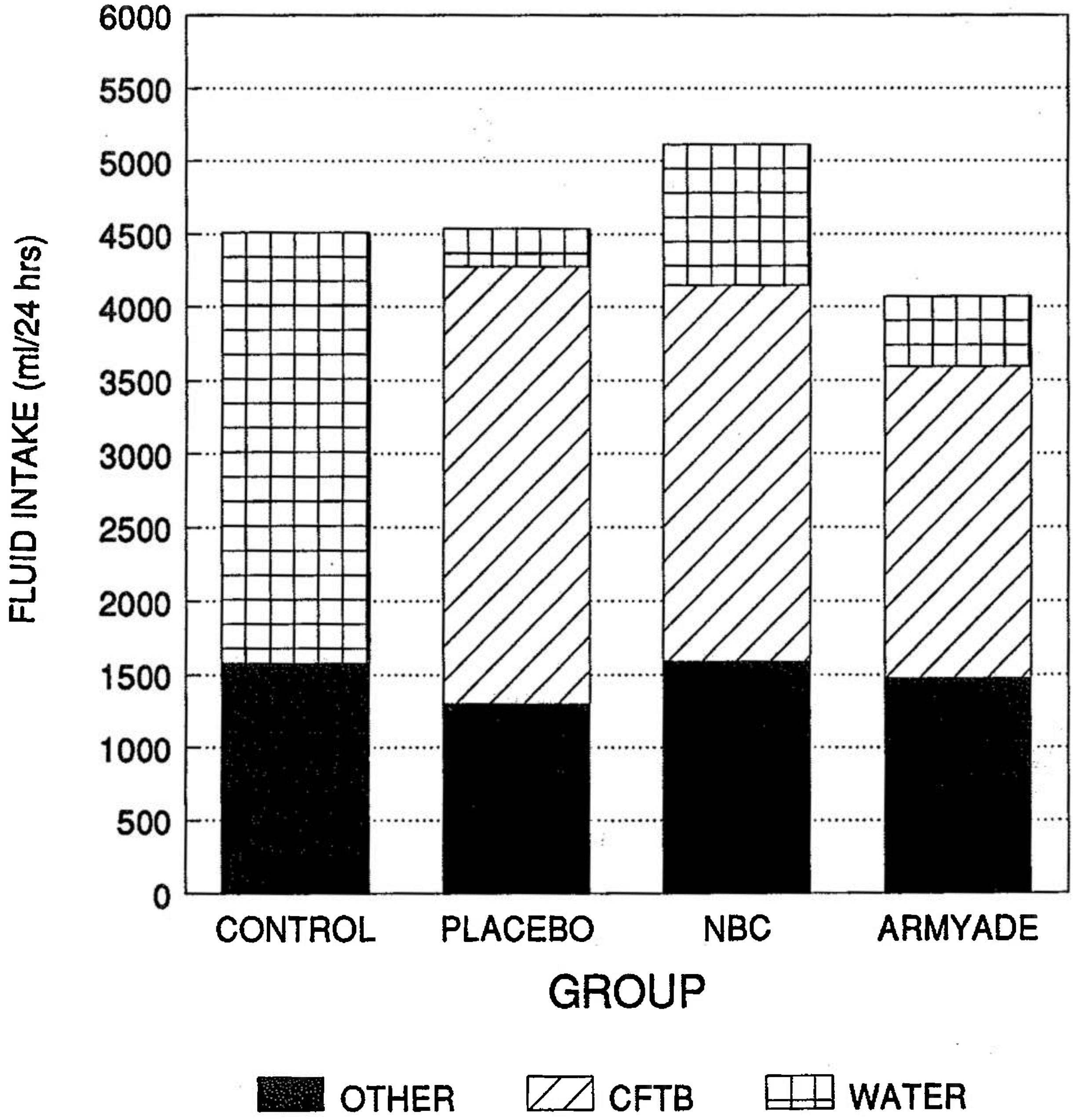

Table 17. Daily total fluid intake (ml/day).

DAY	GROUPS ARMYADE (n=13)	CONTROL (n=15)	PLACEBO (n=11)	NBC (n=16)	MEAN (n=55)
1	3400±365	5121±648	4856±358	5926±703	4895±312
2	4260±524	5042±846	5024±638	5300±401	4928±310
3	4429±474	4734±627	4592±736	5567±660	4876±314
4	4611±578	5374±712	5397±454	6068±607	5400±310
5	3729±470	3972±619	3648±333	4483±421	3998±243
6	4704±652	4100±594	5130±440	5248±447	4783±273
7	3674±500	4446±723	4403±447	4887±517	4383±288
8	3970±589	4037±558	3903±402	4448±558	4114±269
$\bar{x}$±SE	4097±185[a]	4603±235	4619±178	5241±195[b]	4672±104

Means with unlike superscripts differ, p<0.05.

for a summary of the group by day means and standard errors. In particular, note the day to day rank order of the NBC and Armyade values and how that is ultimately reflected in the 1.2 L/day difference in their overall average fluid intakes. While the general F test ($F(3,51)=0.95$, $p=0.42$) is not significant, due primarily to small numbers of individuals in each group many of whom behaved drastically differently from one another, it is still the case that the signficant difference ($p<0.001$) between the NBC and Armyade group found in the one way analysis of variance is valid.

As mentioned, there was a significant difference ($F(7,45)=5.69$, $p<0.001$) over time (Table 17). Except for the Armyade group, fluid intake increased to its highest level on Day 4, the hottest day of the study, then decreased to its lowest level on Day 5 as the temperature decreased. The amount of fluid consumed by all groups

except the Armyade group decreased significantly on the 5th day. This decrease may have been due to the drop in temperature, to the fact that the subjects were given half a day off to return to garrison where they had access to air-conditioning, or to the fact that the subjects were fatigued and did not make an effort to drink.

Estimates of the daily fluid requirements from 0800-2000 hours for the present study period can be found in the Environmental Stress Section of this report. The recommendations for fluid intake (Appendix C) are based on military doctrine and show that generally: <1/2 a quart of water/hr was required on Day 1, about 1/2-1 quart/hr on Days 2 and 3, and >1.5 quarts/hr on Day 4 for the critical 12 hour period when the environmental stress conditions were high. Converting the above quarts/hr to L/hr and using a rate of 0.3 L/hr for WBGT less than 82°F, the intakes for the 12-hour period from 0800-2000 hours for the 8 days should have been: 3.8, 4.4, 5.0, 10.1, 3.6, 3.6, 3.6, and 3.6 L, respectively. The 24-hour fluid intake for the NBC group exceeded the minimum fluid requirements for all days except Day 4. The 24-hour intakes for the other groups (Armyade, Placebo, and Control) did not meet the 12-hour recommendations about a third of the days. The majority of these deficient days occurred around the hottest days (Days 3 and 4), and the incidence of hypohydration was highest (~33%) at that time for the Control (water) and Armyade groups (See Hydration Status Section).

The subjects drinking the NBC solution did not appear to have any gastrointestinal problems with the fructose in the solution. The mean intake for the NBC Nutrient solution was 5241±195 ml/day. There were no reports of gastric upset, epigastric pain, or diarrhea due to the concentration of fructose (1.4%) in the solution.

In the Armyade, Control, and Placebo groups the males drank significantly more daily total fluid than the females $F(1,47)=12.39$, $p<0.001$) (Table 18). The interactions of group, sex, and days were not significant ($F(21,118.28)=0.77$, $p<0.74$); all four groups were increasing and decreasing their fluid intake in similar patterns. One reason for the significant differences between males and females could be the differences in body weight with the males generally weighing more than the females. When the daily total fluid was normalized to the weight of the soldier, there were no significant differences in terms of groups, the interaction of groups with gender, or the interaction of group by day (Table 19). However, the fluid intake was significantly different for gender ($p<0.05$) and over time ($p<0.01$). See Appendix E for information on the analysis of total fluid intake standardized by body weight. Normalizing fluid intake by weight showed the males drinking more than females ($p<0.05$) and all soldiers drinking more on the hottest day of the study (Day 4).

Test Beverage Acceptability Determined by Consumption

The subjects were allowed to bring any beverage to the field exercise. Since they could drink any of the available fluids in any amounts and at any time, the amount consumed was used as a direct estimate of acceptability. The average daily amount of fluid consumed was partitioned into Water, Colored Flavored Test Beverage (CFTB), and Other to determine the relative acceptability of the different test beverages during extended work in the heat (Table 20 and Figure 3). The CFTBs were Armyade, NBC Nutrient solution, and placebo for their respective groups. The test beverage for the Control group had been plain water up to this point in the discussion, but for this special analysis, the Control group had no

Table 18. Daily total fluid intake separated by gender and test beverage group

DAY	GROUPS							
	ARMYADE		CONTROL		PLACEBO		NBC	
	MALE (n=6)	FEMALE (n=7)	MALE (n=6)	FEMALE (n=9)	MALE (n=5)	FEMALE (n=6)	MALE (n=9)	FEMALE (n=7)
1	4023±449	2865±498	6283±1207	4346±655	5591±573	4244±295	6775±897	4835±1046
2	4613±929	3958±609	6894±1513	3807±810	5819±646	4361±1011	5066±612	5336±531
3	5435±601	3566±555	6575±1135	3507±372	5073±1599	3779±738	5453±1030	5500±772
4	5696±935	3680±552	6922±1401	4342±571	5771±680	5085±637	6203±755	5523±1259
5	3851±845	3225±625	4455±880	2920±495	3905±588	2969±368	3854±684	4042±500
6	5108±833	4358±1021	5484±1251	3177±334	5822±565	4553±593	5830±472	4295±879
7	5043±683	2502±315	5123±1143	3481±1044	5001±682	3581±740	5663±684	3888±656
8	5000±976	3088±571	5608±1111	2990±229	4748±404	3198±514	5138±879	3562±471
$\bar{x}$±SE	4846±600	3405±403	5918±1097	3571±422	5216±489	3971±501	5498±468	4623±597

Table 19. Daily total fluid intake normalized to body weight (ml/kg).

VARIATE	MEAN (ml/kg)	SEM	p
Grand Mean	62.3	1.3	0.0001
Group			0.56
Armyade	59.7	2.4	
Control	58.1	2.5	
Placebo	63.9	2.5	
NBC	67.1	2.7	
Gender			0.04
Male	67.0	1.8	
Female	57.7	1.8	
Group by Gender			0.21
Day			0.001
Day 1	66.7	4.0	
2	67.4	4.0	
3	65.2	3.9	
4	72.5	3.7	
5[a]	49.4	2.7	
6	64.4	3.4	
7	57.0	3.7	
8	55.5	2.9	
Day by Group			0.90

[a]Afternoon off

CFTB. Because of the empty cell for CFTB for the Control group, one way analyses were run between groups and between Water, CFTB, and Other to test for statistical significance. A comparison showed significantly ($p<0.001$) larger intakes of CFTB than Water or Other fluids for the Armyade, Placebo, and NBC groups. The pattern of significant differences was the same for the overall means with the Water,

FLUID CONSUMPTION

Table 20. Average daily fluid intake (ml/24 hr) partitioned into type of beverage consumed.

	GROUPS			
	ARMYADE (n=13)	CONTROL (n=15)	PLACEBO (n=11)	NBC (n=16)
WATER	480±64[a,b]	2930±234[d]	256±75[a]	965±114[b]
CFTB[1]	2113±159[d]	--[2]	2974±188[e]	2557±152[d,e]
OTHER	1477±95[c]	1580±82[c]	1306±67[c]	1592±76[c]

[1]CFTB - Colored Flavored Test Beverage (Armyade, placebo, and NBC Nutrient solution).

[2]Since water was the test beverage for the Control group, the CFTB cell is empty for this categorization only.

Within a row or column, Means with unlike superscripts differ, $p<0.05$.

CFTB, and Other values being signficantly different from each other at 1245±90, 2527±97, and 1505±41 ml/24 hr, respectively. The mean intake of CFTB was 4 times as much as the Water intake for the Armyade group, 10 times for the Placebo group, and 2.5 times as great for the NBC group. In terms of the different fluid groups (Water, CFTB, and Other), the amount of Water consumed by the Control group was significantly greater than by the Armyade, Placebo, and NBC groups. This might be expected since the Control group had no CFTB. The subjects in the Placebo group drank significantly more CFTB than the subjects in the Armyade group suggesting that the flavor of the Armyade beverage was not as acceptable and probably affected the daily total fluid consumption. The amount of Other fluids consumed was not statistically different between the 4 groups. For the groups that

had the CFTB, the intakes of CFTB plus Other fluids were much greater than Water intake. It appears that when given a choice, soldiers preferred and drank significantly more colored and flavored beverages (CFTB and Other) than plain water. The intakes of all CFTBs were significantly greater than the Water and Other fluids suggesting a greater acceptability of this type of beverage under light-moderate activity and moderate heat conditions.

When the Control group was given the chance to drink the Other fluids ad libitum to make up for not having a CFTB, they appeared to prefer plain water. Their intake of Other types of beverages was approximately the same as that of subjects in other groups ($p<0.07$). The subjects were given the freedom to drink all the Other fluids that they wanted; however, a reason for the Other fluids being approximately the same for all four groups could be the limited amount of Other fluids that could be obtained and stored in the field.

One subject in the Control group drank unusually large amounts of water. His daily intake of water for all but one day was more than two standard deviations outside the mean, ranging from 6720 to 13440 ml/day. His data increased the mean water intake of that group to 2930±234 ml/day from 2419±158 ml/day. If his data had not been used, the average water intake for the Control group would have been much lower.

The daily hedonic ratings of the Armyade, Placebo, NBC solution, and water consumed by the Control group were obtained from the AM and PM fluid intake cards. The ratings were not statistically different over time and therefore they were pooled for analysis (Table 21). The 9-point Hedonic Rating Scale showed that the Armyade, Control (water), Placebo, and NBC solutions were rated at 5.1, 6.5, 6.6,

Table 21. Hedonic ratings of test beverages.

	TEST BEVERAGES			
	ARMYADE	CONTROL(WATER)[1]	PLACEBO	NBC
N	91	208	86	123
Daily Rating	5.1 ± 0.2^{a}	6.5 ± 0.1^{b}	$6.6\pm0.1^{b,c}$	6.7 ± 0.1^{c}

Note. Mean acceptability ratings are based on a 9-point hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.

[1]Includes water ratings from Control group only.

Means with unlike superscripts differ, $p<0.05$.

and 6.7, respectively. Armyade was rated significantly lower ($p<0.001$) than the placebo, NBC solution, and water (Control group only) at "neither like nor dislike." The NBC, Placebo, and Control (water) beverages were rated between "liked slightly" and "liked moderately" by their respective groups. The NBC group rated the NBC Nutrient solution signficantly higher than the water group rated Water but the difference was less than one rating point. The data in Tables 17 and 21 appeared to follow the hedonic rating trends with the rating for Armyade being significantly less than the other test beverages and also the least consumed. It appears that the acceptability ratings of beverages can significantly affect their consumption.

Considering that the Placebo solution was always several degrees warmer than the Water and several studies (62,63) have shown that cooler beverages are more acceptable, the relative intakes of test beverage and water by the Placebo group clearly show the greater effect of coloring and flavoring on beverage selection (i.e.,

Placebo subjects chose to drink approximately 10x more colored flavored water than plain water). The subjects in the Armyade, Placebo, and NBC groups drank an average of 2527±97 ml of test beverage per day compared to 567 ml of plain water. Including the water drunk by the Control group only increased the mean water intake to 1245±90 ml/day. The subjects were drinking a mean of 2113±159 ml/day of Armyade ranging from a minimum of 0.0 ml/day to a maximum of 7200 ml/day. Of course, one of the subjects in the Control group drank about twice as much fluid with the intake on one day as high as 13,770 ml/day of Water and Other fluids.

Dividing the total amount of test beverage consumed by the total quantity of fluid consumed gives a method of standardizing the amount consumed so that comparisons are possible. The trends of the ratios of test beverage to total fluid consumed also show that the test beverages were acceptable. About 65% of all fluids drunk by the Placebo group was test beverage (Figure 4). For the Armyade and NBC groups the subjects drank smaller amounts or about 50% of their fluids as test beverage (Appendix F). The ratios fluctuated, but the percent of test beverage drunk by the Placebo group was consistently higher than for the other groups. The subjects in the Armyade, Placebo, and NBC groups drank 11.8, 5.6, and 18.9%, respectively, of their total daily fluid intake as water (Table 20), whereas the Control group drank 65% of the total daily fluid as water.

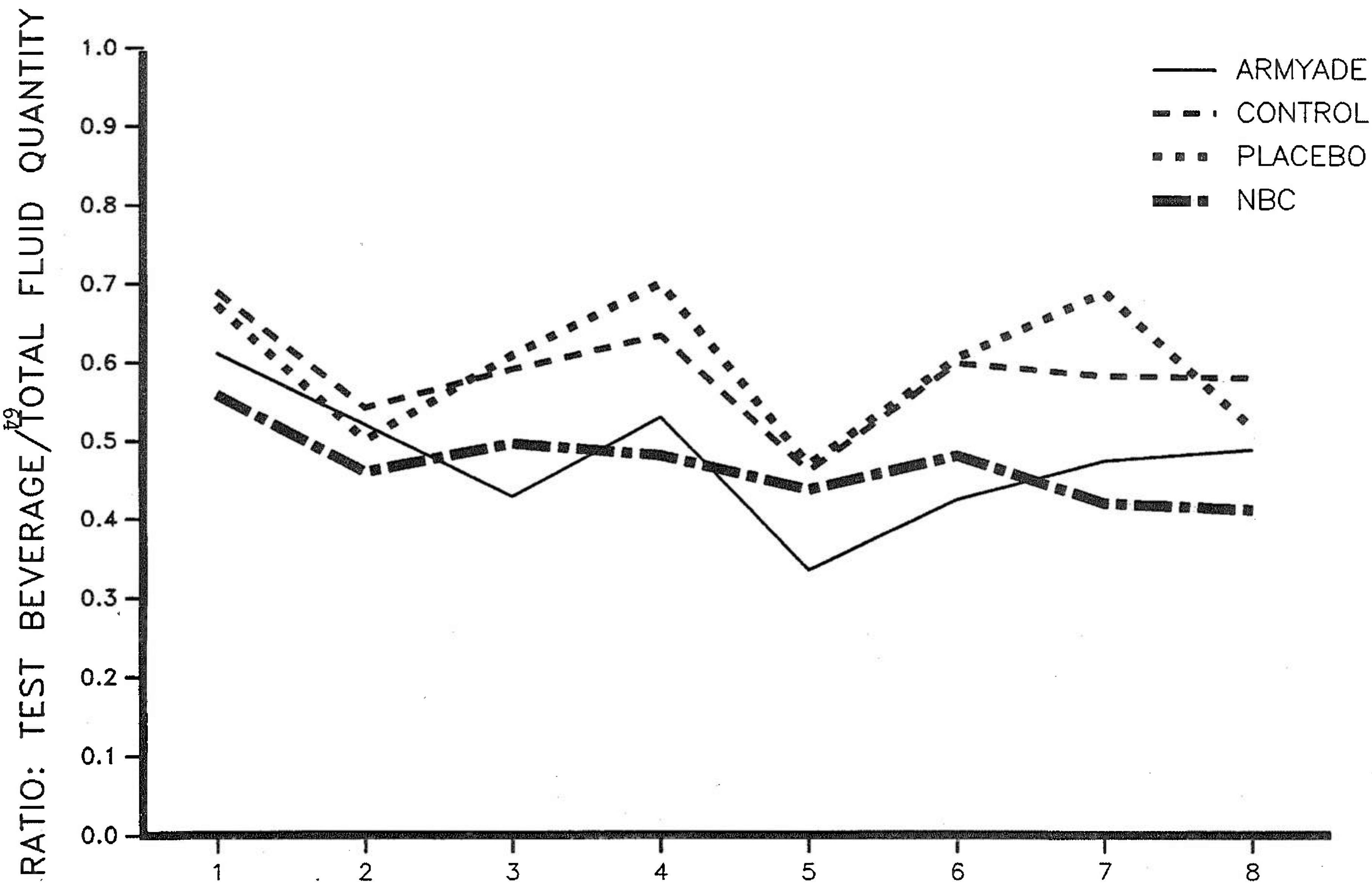

Figure 4. Ratio of test beverage consumption to total fluid intake.

ACCEPTABILITY OF TEST BEVERAGES

ACCEPTABILITY OF TEST BEVERAGES

METHODS

Laboratory Acceptance Test

Subjects. Test subjects were randomly drawn from a volunteer pool of approximately 450 civilian and military employees of the United States Army Natick Research, Development and Engineering Center (Natick) who comprise the Sensory Analysis Section's Consumer Acceptance Panel. Of the thirty-seven subjects who served in this test, 51% were male and 49% were female. Ages ranged from 18 to 39 years. All subjects were naive to the purpose of the study.

Samples. Test samples consisted of the NBC solution, Armyade, the placebo solution (NBC Control), Crystal Light® [2] (sugar free, lemon-lime flavor; General Foods, Inc., White Plains, NY) and Gatorade Thirst Quencher Lemon-Lime Drink® [3] (Stokely-Van Camp, Inc., Chicago, IL). All powdered products were prepared according to manufacturer's or other specified directions, using distilled deionized water. Gatorade, which was bottled in liquid form, required no preparation before use.

All solutions were prepared 24 hours before use and stored in a refrigerator at 41°F. In addition all solutions were maintained and served at 41°F by placing them in metal containers that were embedded in chipped ice throughout the test. The beverages were served in the laboratory at 41°F because chilled beverages tend to be better accepted (13,61-63). Beverages were not chilled in the field; however, the difference between the beverage temperature and the ambient temperature may affect

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2./ Crystal Light® is the proprietary trademark of General Foods, Inc., White Plains, NY. Hereafter, the product will be referred to as Crystal Light.

3./ Gatorade® is a proprietary trademark of Stokely-Van Camp, Inc., Chicago, IL. Hereafter, this product will be referred to as Gatorade.

ratings and therefore efforts were made to create an artificial difference of about 20-30°F that would match the difference between beverage temperature and ambient temperature in the field. Samples consisted of 2 fl oz of solution served in a 5 fl oz polypropylene cup.

Procedure. Panelists were tested in individual sensory testing booths. Ambient temperature was approximately 70°F. The five test samples were presented sequentially and in random order to each subject. Samples were served through a port located in the front of the test booth. Subjects were instructed that upon receipt of the sample, they were to drink the contents of the cup and to rate the solution on each of the following hedonic and sensory attributes: overall acceptability, acceptability of color, acceptability of flavor, degree of thirst quenching, saltiness, sourness, and sweetness. The three acceptability ratings were made using a 9-point hedonic scale (72) where 1=dislike extremely, 5=neither like nor dislike, and 9=like extremely. The four intensity judgments were made using a 9-point category scale of intensity where 1=not present, 5=moderate, and 9=extreme.

All questions and scale options were presented to subjects on CRT screens located in each test booth, and they responded by typing entries on a computer keyboard. Subjects were instructed to rinse their mouths with distilled deionized water between samples, and a thirty second inter-stimulus interval was maintained.

Field Study Final Questionnaire

Procedure. The final questionnaire (Appendix G) was administered to the test subjects in the field on the morning of day 9. The purpose of including a final questionnaire was to obtain the subjects' opinions on general aspects of the test

beverages consumed during the exercise. The final questionnaire also asked for acceptance ratings of water and the test beverages. SPSSx was used to analyze the data collected with the final questionnaire.

RESULTS AND DISCUSSION

Laboratory Acceptance Test

Test beverage acceptance. Table 22 lists the means and standard errors of the ratings given to the five products. One-way analyses of variance with repeated measures (program ANOVSUBJ, version 1.3, 1980, L. Klarman) were performed for each rating scale to determine whether there were any significant differences among the products. Significant differences, as indicated by the F-ratios in Table 22, were found on all scales except acceptability of color. Significant F-ratios were followed by *post hoc* Duncan LSD tests to identify the products which differed from one another.

Armyade was significantly less acceptable than the NBC solution, both overall and in terms of acceptability of flavor. Armyade was also rated as significantly less thirst quenching. Armyade and the NBC solution were rated equally salty and sour, but the NBC solution was perceived as significantly sweeter. Thus, the difference in acceptability between Armyade and NBC solution may be due to the rather large difference in sweetness. On the other sensory dimensions tested, the two products did not differ.

The saltiness of the Armyade and NBC solution undoubtedly contributed to their lower acceptability compared to the commercial products. On the other hand, the placebo was rated no saltier than the commercial products, but was also significantly less acceptable. The placebo did not differ from Armyade in overall acceptability, acceptability of flavor, degree of thirst quenching, or sweetness. The placebo was perceived as significantly less salty and less sour than Armyade. The placebo seemed in general to be characterized by a weak flavor, rating low on saltiness, sweetness, and sourness.

Table 22. Acceptability Ratings of Five Beverages Used in Laboratory Acceptance Test.

	Crystal Light	Gatorade	Placebo	Armyade	NBC	F(4,144)
Overall Acceptability	5.78^{a} (.29)	5.32^{a} (.25)	3.19^{bc} (.32)	2.51^{c} (.26)	3.84^{b} (.31)	28.73*
Acceptability of Flavor	5.65^{a} (.31)	5.46^{a} (.23)	3.16^{c} (.32)	2.43^{c} (.26)	4.00^{b} (.31)	27.65*
Acceptability of Color	4.43^{a} (.30)	4.89^{a} (.30)	5.00^{a} (.31)	4.84^{a} (.34)	5.03^{a} (.33)	0.96
Thirst Quenching	4.92^{a} (.31)	5.14^{a} (.31)	3.16^{bc} (.26)	2.68^{b} (.26)	3.68^{c} (.34)	18.41*
Saltiness	3.43^{a} (.37)	3.70^{ab} (.33)	3.14^{a} (.39)	5.51^{c} (.40)	4.62^{bc} (.42)	7.40*
Sourness	6.27^{a} (.27)	4.54^{b} (.28)	3.05^{c} (.36)	3.92^{bd} (.41)	3.62^{cd} (.35)	19.04*
Sweetness	4.68^{a} (.37)	4.62^{a} (.29)	2.46^{b} (.26)	3.08^{b} (.32)	4.81^{a} (.28)	14.86*

Note. Mean acceptability ratings are based on a 9-point hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.

Mean intensity judgements are based on a 9 point rating scale where 1 = not present, 5 = moderate, and 9 = extreme.

Beverages that differ significantly from one another ($p<0.05$) have different superscripts.

Numbers in parentheses are standard errors.

* $p<0.01$

The placebo and NBC solution did not differ in terms of overall acceptability, degree of thirst quenching, and sourness. However, the placebo was perceived as significantly less salty and less sweet. The difference in acceptability of flavor was significant, suggesting that the NBC solution had a somewhat more acceptable flavor than the placebo. No prior experimentation had been performed in order to match the placebo to the NBC beverage from a consumer point of view. Although the acceptability ratings are significantly different, the differences are very small. Thus, while the products differ in terms of some of their sensory characteristics, they are reasonably well matched in terms of acceptability.

The commercial products (Crystal Light and Gatorade) differed significantly only in sourness (Crystal Light was significantly more sour); otherwise, there were no significant differences between them.

Both commercial products rated higher in overall acceptability, flavor acceptability, and degree of thirst quenching than any of the military products. Both were rated as less salty than the military nutrient solutions (NBC and Armyade), and about as salty as the placebo. The Crystal Light product and the placebo did not contain any electrolytes and thus the less salty rating was expected. The commercial products were perceived as sweeter than the placebo and Armyade, but no sweeter than the NBC solution. In terms of sourness, Crystal Light was rated the most sour of all five products, with Gatorade second. Gatorade was rated more sour than the placebo and the NBC solution, but the same as Armyade.

It is interesting to note that neither the commercial products nor the NBC beverage received highly favorable acceptance ratings (all average acceptability ratings below 6.0=like slightly). These findings are unusual in two respects. First, one would expect successful commercial products to score higher. Secondly, the NBC

solution has received higher ratings in previous tests. However, those tests were conducted with military subjects in hot environments or with subjects who were wearing MOPP gear. In a hot environment, aspects of the NBC beverage that make it unacceptable in a laboratory environment may not matter, possibly because of the expected benefits of a nutrient beverage. Similarly, Gatorade, which is marketed as a nutrient beverage, can be expected to score higher under conditions more similar to those for which it was intended (e.g. after physical exertion). Crystal Light, while rated higher than most of the other products, was also not rated above 6.0 on average, even though it does not share some of the properties of the nutrient beverages (e.g. saltiness). The reason for the low score for the Crystal Light, which is marketed as a low calorie beverage, is not clear.

Field Study Final Questionnaire

Self-reported liquid and food intake. The percentages of subjects in each group that reported drinking and eating sufficient amounts during this exercise are shown in Table 23. The four groups were quite similar in these respects. In all cases, 65% or more of the subjects reported having enough to drink and eat.

Of those that reported that they did not have enough to drink, many gave a variety of reasons including having to go too far to pick up the water, not liking the beverage provided, and finding the liquid (Water, Test Beverage, or Other fluids) too warm to drink. In regards to the temperature of the liquids consumed, Table 24 provides the mean temperature ratings assigned to the various drinks by each of the four groups. One-way analyses of variance conducted with these data indicated that there were no marked differences between the groups in terms of their perceptions of the temperature of the liquids available to them during this exercise.

Table 23. Percentage of subjects in each group that reported drinking and eating sufficient amounts during this exercise.

	GROUPS			
	CONTROL (n=14)	PLACEBO (n=12)	ARMYADE (n=15)	NBC (n=17)
	%YES	%YES	%YES	%YES
Drank as much as wanted/needed	77	75	67	69
Ate as much as wanted/needed	71	92	67	65

Note. Table entries represent percentages of subjects that responded to the question.

Table 24. Mean temperature ratings of liquids consumed during this exercise.

	CONTROL (n=14)	PLACEBO (n=12)	ARMYADE (n=15)	NBC (n=17)
Liquid in Canteen (water, placebo,or nutrient solution)	4.1 (.48)[a]	4.3 (.36)	4.9 (.29)	4.3 (.24)
Cold Drinks Served With Breakfast (milk, juice, etc.)	2.4 (.20)	2.8 (.40)	2.3 (.23)	2.4 (.27)
Cold Drinks Served With Dinner (Koolaid, juice, etc.)	2.4 (.17)	2.6 (.28)	2.2 (.20)	2.3 (.22)

Note. Means in this table are based on a 7-point rating scale where 1 = cold, 4 = neutral, and 7 = hot. See Appendix G for the descriptions associated with the ratings.

[a] Numbers in parentheses are standard errors.

ACCEPTABILITY OF TEST BEVERAGES

Cold drinks served with the breakfast and dinner meals were generally perceived as moderately to slightly cool, whereas the liquids that subjects carried in their canteens were rated as neutral to slightly warm.

Of those subjects that reported that they did not have enough to eat, at least one subject from three of the groups indicated that he did not like the food in the MRE. Previous field evaluations of the acceptability of the MREs provided to subjects in this study have identified several features of the ration that require modification (73). The newest version of the MRE, the Improved MRE, will satisfy these needs by including greater variety and larger portion sizes in the entrees, two breakfast entrees, wet pack fruits instead of dehydrated fruits, and fruit flavored beverages in all menus. According to the current distribution schedule, the Improved MREs will be available to troops in 1991.

Subjects were also asked to rate how often they were thirsty and how often they were hungry. The data obtained from these inquiries are summarized in Table 25. A one-way analysis of variance of the thirst ratings did not reveal any significant differences between the four groups. However, as can be seen in Table 25, subjects that drank Armyade tended to be thirsty somewhat more frequently than did subjects that drank other liquids. On the average, subjects in the Armyade group reported that they were often thirsty ($\bar{x}$=5.2), whereas subjects in the other groups reported that they were sometimes to fairly often thirsty (i.e., at or below the mid-point on the scale). The tendency of subjects in the Armyade group to express slightly higher thirst ratings is probably related to the findings that Armyade received lower acceptance ratings, daily and on the final questionnaire, and was consumed in smaller quantities than the other test beverages. The acceptability data collected on the final questionnaire will be discussed in detail below.

Table 25. Mean ratings of self-reported thirst and hunger.

	CONTROL (n=14)	PLACEBO (n=12)	ARMYADE (n=15)	NBC (n=17)
Frequency of self-reported thirst	4.1 (.31)[a]	3.7 (.31)	5.2 (.83)	3.4 (.30)
Frequency of self-reported hunger	3.2 (.37)	2.8 (.25)	3.6 (.34)	3.1 (.33)

Note. Means in this table are based on a 7-point rating scale where 1 = never, 4 = fairly often, and 7 = always. See Appendix G for the descriptions associated with the ratings.

[a]Numbers in parentheses are standard errors.

The groups also did not differ in terms of the self-reported ratings of hunger (NS). Consistent with the subjects' report that they generally ate as much as they needed/wanted (Table 23), they also reported that they were sometimes hungry which is below the mid-point on the scale.

Test beverage acceptance. The acceptability of water and the three test beverages was assessed using a 9-point hedonic rating scale which ranges from 1=dislike extremely to 9=like extremely. The mean acceptability ratings and corresponding standard errors for the three groups that consumed a test beverage are shown in Figure 5. A one-way analysis of variance indicated that the groups differed in terms of acceptance ratings ($F(2, 40)=4.2$, $p<0.05$). *Post hoc* comparisons conducted by the Student-Newman-Keuls method showed that Armyade was rated reliably less acceptable ($p<0.05$) than either the placebo or the NBC solution. The average rating for Armyade ($\bar{x}=5.1$) corresponded to the neutral point on the scale (neither like

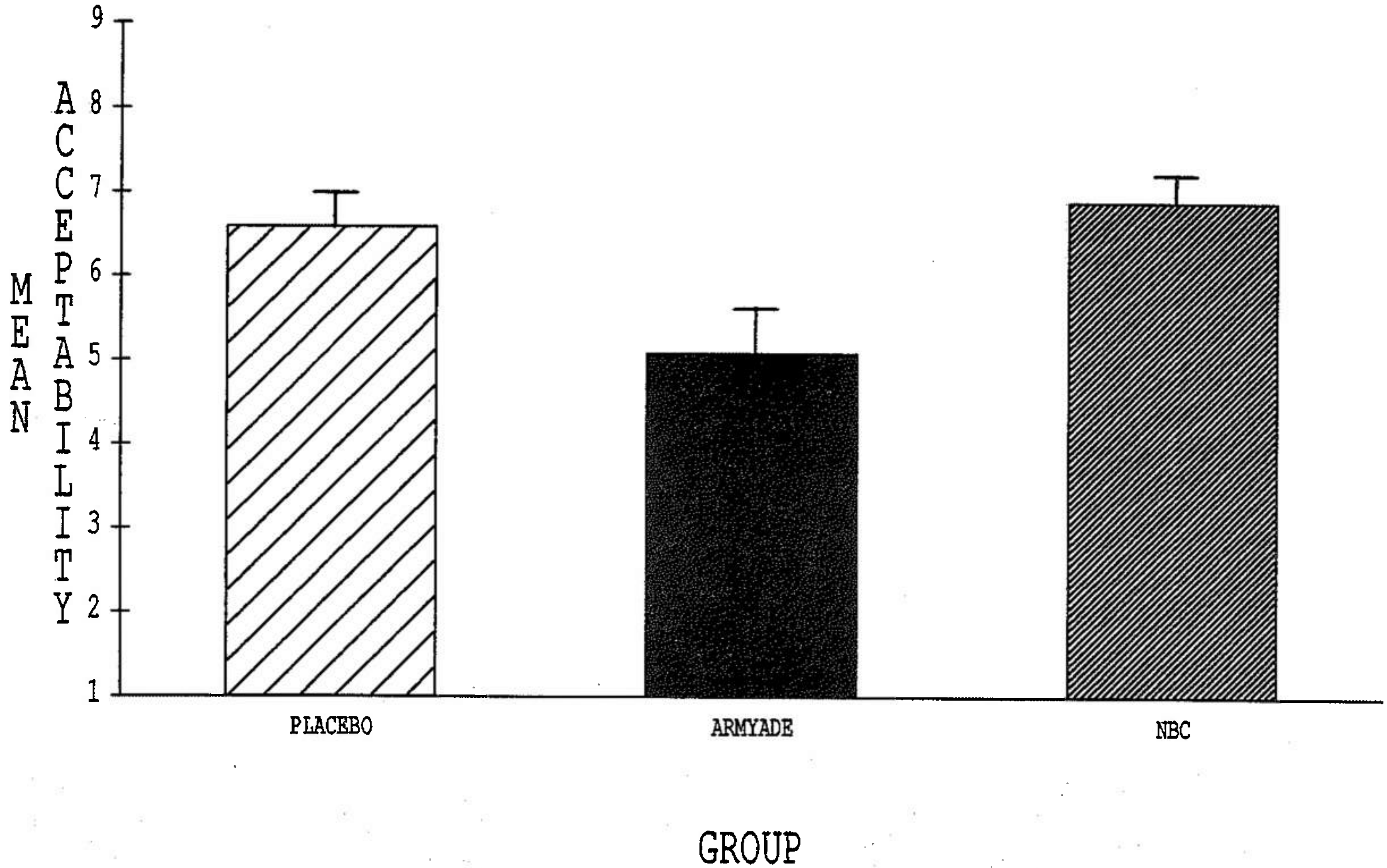


Figure 5. Mean acceptability ratings of test beverages consumed during this exercise (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely).

nor dislike). The average ratings for the placebo ($\bar{x}$=6.6) and the NBC nutrient solution ($\bar{x}$=6.9) were on the positive end of the scale (like moderately). These findings parallel those reported from the daily acceptance ratings of the test beverages and are also consistent with those from the taste test conducted at Natick. In the laboratory acceptance test, Armyade received significantly lower ratings than the NBC solution and commercial beverages. Acceptability ratings of Armyade did not differ from those of the placebo in that test. As discussed earlier, the fact that acceptability ratings were generally higher under field conditions than under laboratory conditions suggests that soldiers working in a hot environment tend to be less critical of any beverage that is offered, perhaps due to the expected benefits of consuming the beverage (74).

In an effort to discover why Armyade received lower ratings than the placebo and the NBC nutrient solution, the groups were also compared in terms of their ratings of the acceptability of water. It may have been the case that subjects in the Armyade group tended to rate any drink lower than did subjects in the other two groups. Figure 6 illustrates the comparison between Water and Test Beverage acceptability ratings for the three groups that consumed a test beverage. Although it appears that the Armyade group did tend to rate water, as well as Armyade, somewhat lower than did the other groups, a one-way analysis of variance of the water acceptability ratings indicated that this difference was not statistically significant (mean water acceptability ratings: Armyade $\bar{x}$=5.3, Placebo $\bar{x}$=6.2, NBC $\bar{x}$=6.6). In short, the fact that Armyade was not favorably received in this study does appear to reflect some undesirable property of the beverage rather than a group tendency to assign low ratings.

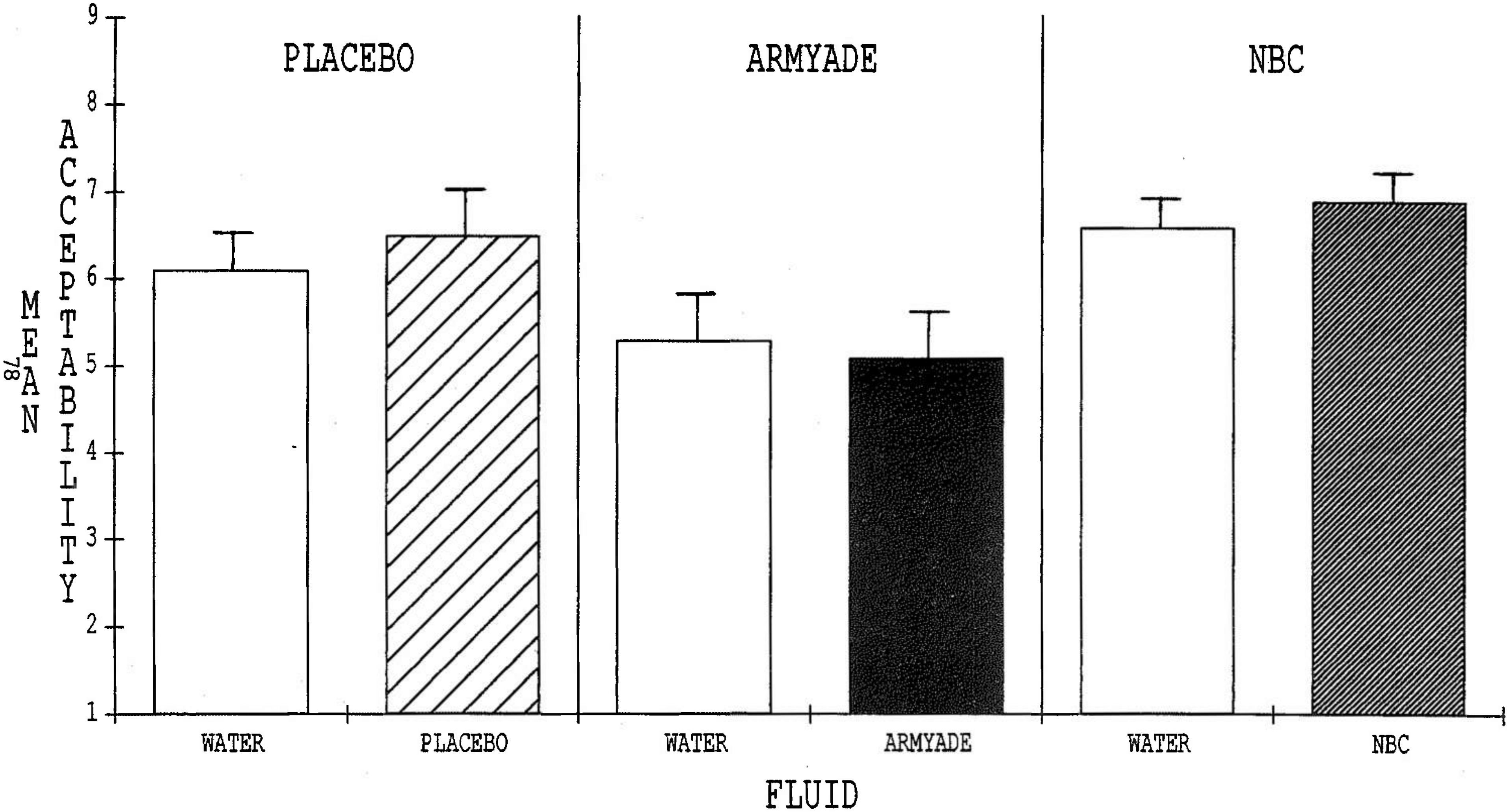


Figure 6. Comparison of water acceptability ratings to test beverage acceptability ratings by group (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely).

The subjects in the three groups that drank a test beverage were also asked to use a 6-point scale (1=not at all salty, 6=extremely salty) to rate the saltiness of the beverage they consumed. A one-way analysis of variance with accompanying <u>post hoc</u> comparisons (Student-Newman-Keuls, $p<0.05$) indicated that Armyade was perceived as significantly more salty than the placebo ($F(2,41)=6.1$, $p<0.01$). Armyade received a mean rating that corresponded to somewhat salty ($\bar{x}=3.0$), whereas the placebo was rated as not at all to slightly salty ($\bar{x}=1.3$). Ratings for the NBC solution fell in between these two at slightly salty ($\bar{x}=2.2$). These data are illustrated in Figure 7. When asked to indicate what they thought about the amount of saltiness in the drink, subjects in the Armyade group and the NBC group both gave mean ratings that were above the neutral point on the scale (7-point scale, 1=much too little, 4=just right, 7=much too much). However, there were no reliable differences between groups in their replies to this question (Armyade $\bar{x}=4.4$, Placebo $\bar{x}=3.8$, NBC $\bar{x}=4.5$).

These findings are very similar to those reported from the laboratory acceptance test conducted at Natick and suggest that the perceived saltiness of Armyade probably decreased its overall acceptability and contributed to the lower intake noted for subjects in that group during the field test. The results obtained from the laboratory acceptance test also indicated that the test beverages used in this field study differed in terms of sweetness. The NBC solution was rated as significantly sweeter than the placebo and Armyade in the laboratory test. The beverages were not found to differ significantly on this dimension in the field test.

<u>General comments and recommendations</u>. Not surprisingly, subjects in the Armyade group ($\bar{x}=2.7$) and the NBC group ($\bar{x}=3.0$) reported needing (or perhaps, wanting)

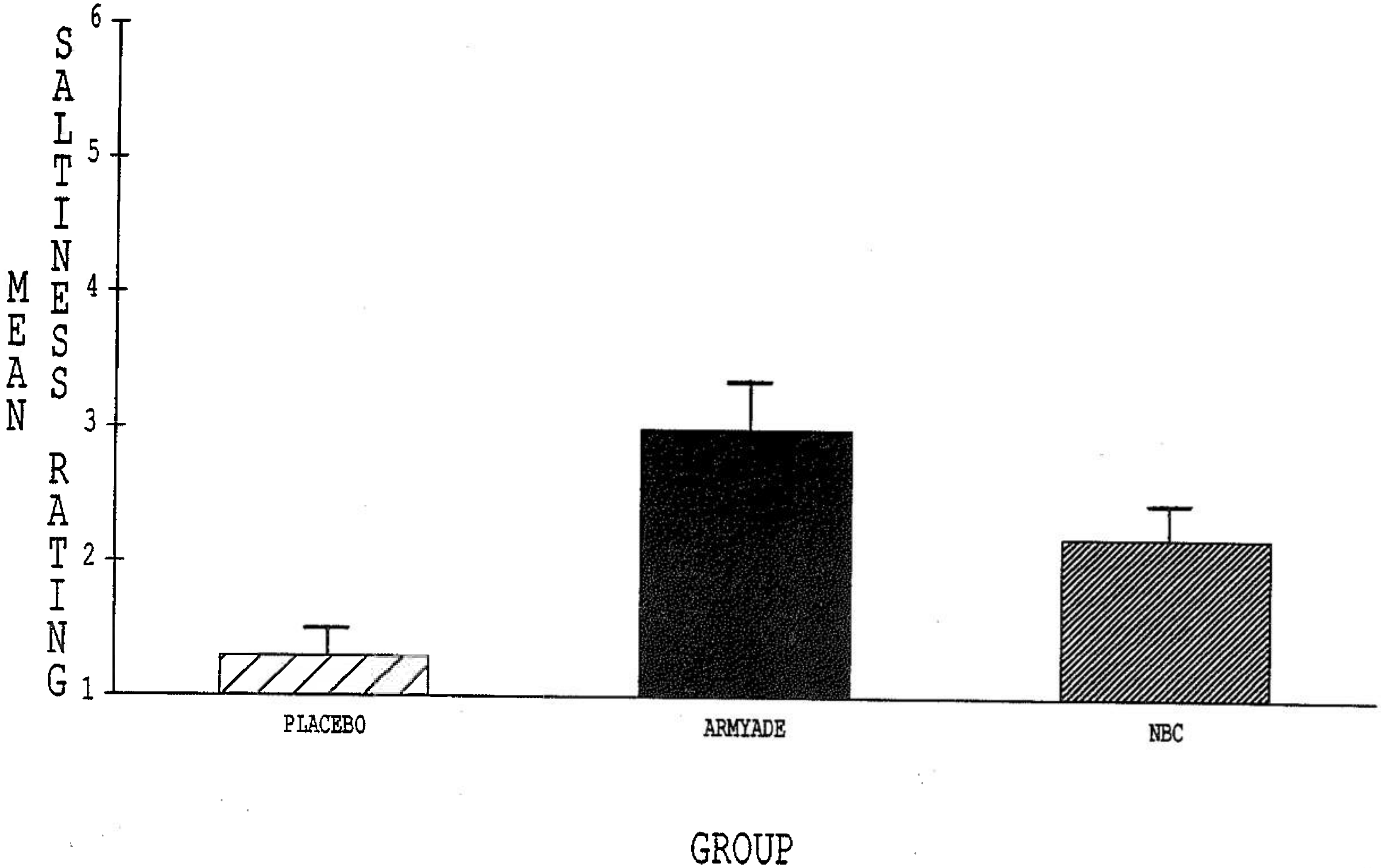


Figure 7. Mean saltiness ratings of test beverages consumed during this exercise (1 = not at all salty, 6 = extremely salty).

significantly less of the test beverage than did subjects in the placebo group ($\bar{x}$=4.2) ($F(2,39)=6.4$, $p<0.01$). These results are shown in Figure 8 (7-point scale, 1=needed much less, 4=amount just right, 7=needed much more). Subjects in the Armyade group and the NBC group did not differ from subjects in the placebo group in terms of the amount of energy they felt they gained from the test beverage. All reports indicated that the three test beverages provided about the same or slightly more energy than water even though the placebo did not contain any calories. Although the three groups did not differ, all felt that the test beverage was slightly better than water at replacing body fluids lost by sweat. This opinion may have been influenced by the fact that they had been told during their briefings that they were testing carbohydrate-electrolyte beverages.

As would be expected from the acceptability data discussed above, subjects in the Armyade group recommended decreasing the salt content of the test beverage. Suggestions were mixed on the issue of sweetness. Independent of group assignment, subjects also recommended increasing the variety of flavors offered. Subjects suggested that the beverages be made available in cherry, lemon-lime, orange, and grape flavors. This suggestion is worth pursuing since previous work has indicated that variety enhances fluid intake in humans (75). Although the NBC solution is available in a variety of flavors, flavor was held constant in this study because Armyade is only available in one flavor.

Comparison to Previous Acceptability Tests of NBC Nutrient Solution

The acceptability results obtained in the present study can be compared to those obtained in previous laboratory and field tests of the NBC solution. For example, in a recent study (53) the NBC solution was tested against a colored, flavored

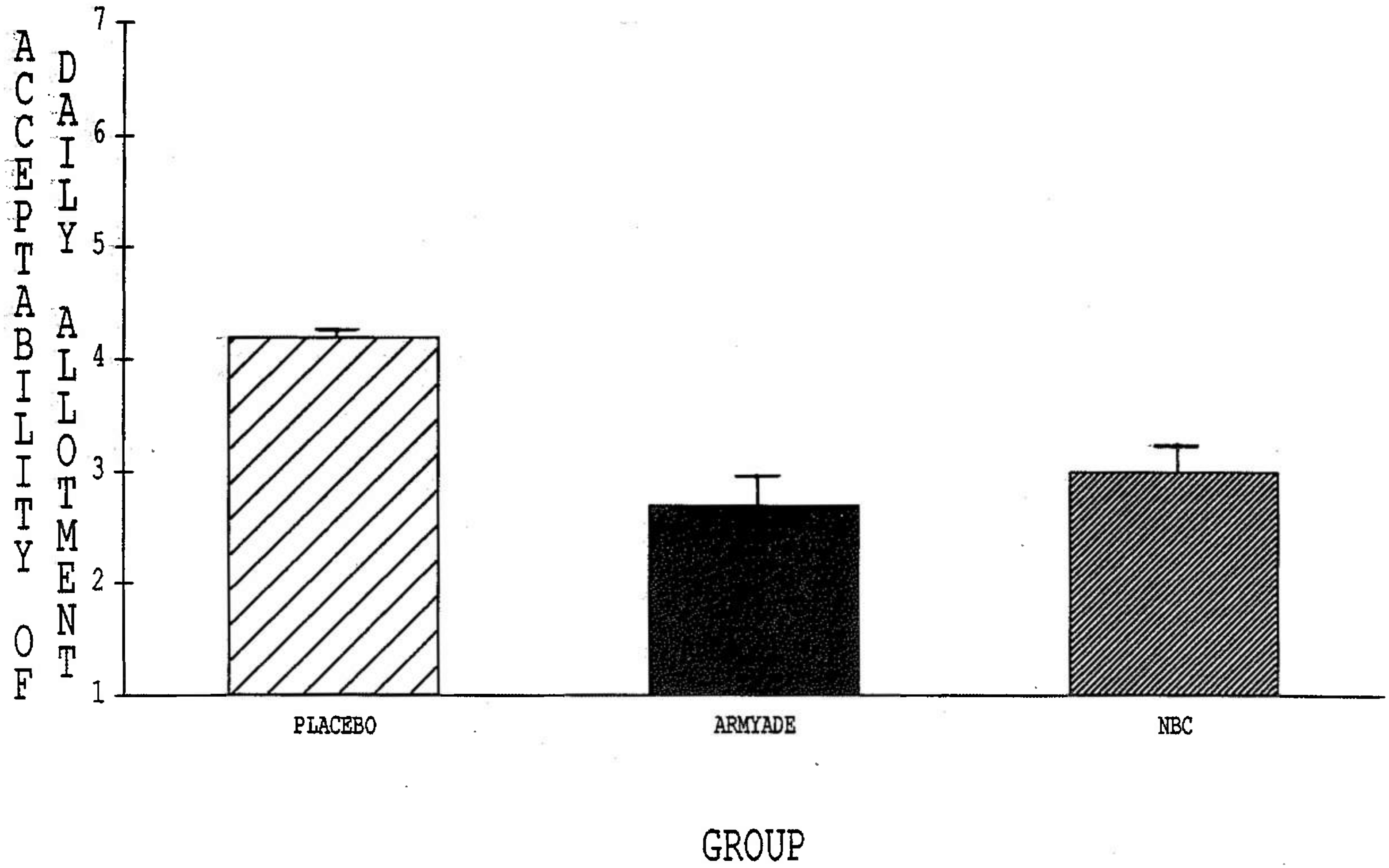


Figure 8. Mean acceptability ratings of the quantity of test beverage issued daily (1 = needed much less, 4 = amount just right, 7 = needed much more).

control (no natural or artificial sweetener added) with subjects exercised at 400 watts in a climatic chamber (98° F, 20% rh, 2 mph wind speed) for up to 24 hours. However, unlike the present study, in which ad libitum consumption was allowed, the previous study employed a forced drinking regimen. A comparison of both the daily acceptance ratings ($\bar{x}$=6.7) and the post-test acceptance ratings ($\bar{x}$=6.9) of the NBC solution in the present study with ratings of the NBC solution in the previous study ($\bar{x}$=6.3) show good agreement. However, the addition of aspartame to the placebo solution in the present study produced much higher acceptance ratings ($\bar{x}$=6.6 for both daily and post-test ratings) then were obtained for the sweetener-free control in the previous study ($\bar{x}$=4.0).

The acceptance ratings for the NBC solution can also be compared to previous laboratory and field studies in which the acceptance ratings for these solutions were obtained from subjects who were in MOPP4 and who consumed them through the drinking tube on their face respirators. These data show mean acceptance ratings of 5.8 at the CANE Exercise at Fort Ord, CA in 1983 (76), 5.7-5.8 at the REDLEG Demonstration at Fort Sill, OK in 1986 (77) and 5.8-6.1 in laboratory tests at Natick (77). While still acceptable, these values are lower than those found in the present field study and in the previous climatic chamber study (53). One possible explanation for these differences is that the difficulty and stress of drinking when in MOPP4 may cause a reduction in the overall acceptance of these beverages through generalization of effect. Future studies of the NBC solution should certainly look at the role that consumption mechanics may play on both fluid consumption and acceptance of alternative solutions.

The data obtained from the laboratory test of acceptance in the present study is consistent with both the field acceptance data and the previous chamber data (53) in

showing that the NBC solution ($\bar{x}$=3.84) scored higher in acceptance than the placebo or control ($\bar{x}$=3.19), although the difference is not statistically significant. However, unlike the field and chamber data, the absolute acceptance ratings for both the NBC and placebo solutions are dramatically lower. The reason for this lies in the difference in the test subject populations and the environmental and situational conditions of the tests. In the laboratory acceptance test the subjects were comprised of both civilian and military personnel, were tested in a cool, comfortable laboratory setting, and were presented the beverages in conjunction with two well-liked commercial beverages. In both the present field test and the previous chamber study military subjects tested the solutions under high heat stress conditions and without a direct basis for comparison with commercial counterparts. It has long been held that laboratory acceptance panels are more critical towards foods and beverages than field panels (78). This fact, combined with the contrast effect of presenting these products together with well-liked commercial beverages (Crystal Light and Gatorade) are what is likely responsible for the very low ratings of the NBC solution and placebo in the laboratory acceptance test.

Two last points should be made concerning the acceptability data from this test and previous work. The first concerns the relationship between the acceptability of each of the beverages/solutions and the availability of water. It is very likely that the acceptance and, ultimately, the consumption of any nutrient fluid is dependent upon the availability of plain water to drink. In previous lab and field studies (76,77) it has been shown that, given the choice of a nutrient solution, nutrient solution plus plain water, or plain water only, subjects will decidedly choose in favor of having both fluids available. The reason for this is that while the usually fruity or tart flavor of a nutrient solution is a welcome addition to water, especially when the water is

chlorine or iodine-treated, exclusive consumption can lead to sensory specific satiety and a strong desire to "rinse" the mouth with plain water. Studies that are conducted with forced or ad libitum drinking of a single nutrient solution, without plain water available, may result in markedly lower acceptance and consumption than was found in the present study. The second point relates to the "placebo effect" and the need to conduct double-blind tests. The "placebo effect", in which physiologically innocuous substances are given to patients who believe themselves to be receiving physiologically active substances, has been shown to produce both behavioral and physiological effects in those subjects, and these effects have been shown to be consistent with the subject's belief about the nature of the expected effects (74). In future studies of the NBC solution, double-blind procedures should be implemented to ensure that experimenters and field technicians are not aware of the treatment condition for the subjects. If this is not done, information about the condition can inadvertently be passed on to the subjects (79), who will then be susceptible to a "placebo effect."

CONCLUSIONS

1. Field and laboratory acceptance data were consistent in showing the NBC solution to be significantly more acceptable than Armyade. Acceptability ratings of the placebo were intermediate to those of Armyade and the NBC solution in both tests.
2. Since the laboratory and field data were consistent in demonstrating that the perceived saltiness of Armyade was too intense, it is recommended that additional formulation studies be conducted to optimize the sensory characteristics of this solution.

3. Future field tests should employ a double-blind procedure and should limit fluid consumption to only the test solutions and control fluids.

NUTRITIONAL INTAKE

NUTRITIONAL INTAKE

METHODS

Food intake data were collected at the breakfast and dinner meals using a modified visual estimation method (MVEM) developed at USARIEM (80). In this method the subject selected his food, showed his tray to the data collector, ate his meal, and showed his tray to a data collector again. Data on food and fluids consumed with meals were recorded on a ration record form (Appendix H) by the data collector who was able to estimate portion sizes to within a tenth of a standard portion. Each data collector was responsible for approximately 15 subjects so that there was minimal interference in the schedule of the soldiers in terms of long lines and cold food during the meal period. Subjects recorded between meal food intake on the fluid intake card (Appendix D). All extra foods brought to the field, purchased from the PX mobile kitchen, and eaten at restaurants or fast food establishments were recorded on the card. The Meal, Ready-To-Eat (MRE) ration (version VI, 1986 procurement) was available for the lunch meal. All the MRE food items were pre-printed on the fluid intake card and the subjects were asked to circle the food and amount eaten.

A-rations were served at the breakfast and dinner meals. The MRE was given to the soldiers at the breakfast meal for use at the lunch meal. On Day 5 the breakfast and lunch meals were A-rations and the MRE was issued for the Dinner meal; however, because of the opportunity to eat at a variety of on-post eating establishments, most of the soldiers did not eat the MREs.

RESULTS AND DISCUSSION

The effects of carbohydrate-electrolyte solutions on work in the heat are affected by the adequacy of dietary intakes and therefore the nutritional adequacy of the diet was determined.

Meal Attendance Data

Collection of the data on food eaten at meals served by food service personnel and between meals was 98% complete. Data were collected on 100% of the meals served by the food service personnel but 4% of the between meal data forms were missing (Appendix I). A majority of the missing forms were from the PM period which covered the period from after supper until breakfast the next morning. Between meal food items were consumed until bedtime but less fluid was consumed during this time period so the loss of this data should not drastically affect the means. The missing data will cause the energy and fluid intake to be slightly underestimated. Data were collected on all subjects who ate meals served by food service personnel, but of the 976 possible breakfast and dinner meals (61 subjects x 8 days x 2 meals) that could be consumed during the study period, 13% were skipped. Breakfast was the meal that was most often skipped. Since all soldiers were wakened and gathered in formation just prior to the breakfast meal, skipping the breakfast meal was probably deliberate. Some soldiers were scheduled for early classes in garrison and left the area before breakfast was served but this was very seldom. Table 26 shows the number of subjects that skipped a certain number of meals. Only 17 subjects or 28% of the sample ate all hot meals that were served by the food service personnel. About 85% of the soldiers skipped 3 meals or less of a possible 16 (2 meals/day x 8 days). Data for the present study show that one

person skipped 11 meals and another skipped 15 meals. The subject who skipped 15 meals had come prepared to miss all meals. She was attempting to lose weight and had brought her own food: yogurt, distilled water, skim milk, etc. The subject who skipped 11 meals was involved in coordinating administrative details of the FTX

Table 26. Distribution of subjects according to the number of food service meals skipped[a].

NUMBER OF SERVICE MEALS SKIPPED	NUMBER OF SUBJECTS SKIPPING FOOD MEALS (N=61)
0	17
1	15
2	10
3	10
4	2
5	2
6	2
7	1
8	0
9	0
10	0
11	1
12	0
13	0
14	0
15	1
16	0

[a]Food intake data were collected two times a day for 8 days for a maximum of 16 meals.

and skipped many hot food service meals, but he was eating in garrison and recording his food intake on the fluid intake/between meal food card.

Energy Intake

The daily caloric intake from all foods and fluids to include the test beverages was not significantly different ($F(3,51)=0.45$, $p=0.72$) between groups but was significantly different over time ($F(7,45)=7.26$, $p<0.001$) (Table 27). Caloric intake increased to the third day for all groups then decreased significantly ($p<0.05$) to Day 7 for the Armyade and Control groups. The interaction of group with time was not significant ($F(21,129.77)=1.13$, $p=0.33$). For all groups, the caloric intake dropped on the hottest day of the study. The mean energy intakes of all groups were very similar. The mean intake for all soldiers involved in the study was 2680±48 kcal/day which is well below the Military Recommended Dietary Allowances (MRDA)

Table 27. Total energy intake (kcal) from all foods and fluids consumed during 8 days of work in the heat.

	GROUPS				
DAY	ARMYADE (n=13)	CONTROL (n=15)	PLACEBO (n=11)	NBC (n=16)	MEAN (n=55)
1	2675±321	2389±313	2653±244	2963±298	2676±150
2	3160±250	2742±325	3081±280	2963±284	2973±144
3	3624±275	3072±346	2929±230	2986±256	3149±145
4	2414±254	2262±192	2895±170	2799±272	2581±120
5	2724±369	2460±285	2602±193	2502±196	2563±133
6	2949±342	2456±261	2799±192	2825±283	2749±139
7	2522±294	2025±224	2184±199	2253±173	2241±112
8	2335±233	2690±228	2722±285	2334±196	2509±115
$\bar{x}$±SE	2800±108	2512±99	2733±82	2703±89	2680±48

of 3200 kcal/day set for moderately active military male personnel, ages 17 to 50 years (81). The daily caloric intakes ranged from a minimum of 137 kcal/day for one subject in the Armyade group to a maximum of 6162 kcal/day for one subject in the the Control group. A mean of 2680±48 kcal/day is low compared to the energy intake of previous field studies where mean intakes of subjects consuming 2 A-ration meals + 1 MRE ration/day for extended periods (5-6 weeks) have been reported to be 2950 and 3271 kcal/day (64,82). A mean intake of 3713 kcal/day was reported for field artillery soldiers fed 3 A-ration meals during 8 days of sustained artillery operations in the field (46).

The most probable reason for the lower energy intake in the present study is that approximately half of this sample were women, whereas all other previous studies were done on males. Females do not require as many calories as males because of their lower body mass. Comparing the mean caloric intake for males (3056±74 kcal) in the present study (Table 28) to previous field studies showed that energy intakes were similar. The mean caloric intakes for the present study were very similar to previous garrison dining facility studies (83,84). The female intakes at 2343±55 kcal/day (SEM) were much lower than male intakes, but very close to the 2467±560 kcal/day (SD) of the female basic trainees at Fort Jackson, SC (85).

Although there were no group differences for energy intake (Table 29), there were significant differences ($F(1,47)=20.33$, $p<0.001$) between males and females (Appendix J). To determine if the differences were related to body size, the total energy intake was divided by body weight. Appendix K shows that there were no significant differences between gender, groups, and group by gender when intake was normalized to body weight.

Table 28. Comparison of mean nutrient intake to Military Recommended Dietary Allowances (MRDA).

VARIABLE	POOLED SUBJECTS MEAN±SEM	MALE MRDA	MALE MEAN±SEM	FEMALE MRDA	FEMALE MEAN±SEM
Energy (kcal)	2687 ± 46	2800-3600	3056 ± 73.8	2000-2800	2343 ± 54.8
Protein (g)	96.9 ± 2.3	100	113.1± 3.1	80	82.4± 3.1
Carbohydrate (g)	363.6 ± 6.8	—	403.5± 10.8	—	327.8± 7.9
(%)[b]	54	50-55	53	50-55	56
Fat (g)	95.3 ± 2.1		112.1± 3.0	—	80.3± 2.5
(%)[b]	32	<35	33	<35	31
Cholesterol (mg)	515.9 ± 14.9	—[a]	581.4± 22.1	—[a]	457.2± 19.5
Thiamin (mg)	2.2 ± 0.1	1.6	2.6± 0.1	1.2	1.9± 0.1
Riboflavin (mg)	2.3 ± 0.1	1.9	2.7± 0.1	1.4	2.0± 0.1
Niacin (mg NE)	24.9 ± 0.6	21	28.2± 0.8	16	22.0± 0.8
Vitamin C (mg)	169.9 ± 6.9	60	167.5± 9.6	60	172.0± 9.8
Vitamin B_6 (mg)	1.9 ± 0.1	2.2	2.1± 0.1#	2.0	1.7± 0.1#
Vitamin B_{12} (mcg)	3.9 ± 0.1	3	4.3± 0.2	3.0	3.5± 0.2
Vitamin A (mcg RE)	997.6 ± 32.2	1000	1088.4± 47.9	800	916.1± 42.7
Iron (mg)	16.2 ± 0.4	10-18	18.6± 0.5	18	14.1± 0.5#
Calcium (mg)	1215.7 ± 29.2	800-1200	1416.7± 43.9	800-1200	1035.6± 35.1
Magnesium (mg)	343.2 ± 9.1	350-400	406.8± 15.7	300	286.2± 8.4#
Phosphorous (mg)	1738.1 ± 36.8	800-1200	2016.8± 56.7	800-1200	1488.3± 41.6
Sodium (mg)[b]	4227.3 ± 91.1	<5500	5005.9±128.3	<4100	3529.3±110.7
Potassium (mg)[b]	3358.6 ± 72.8	1875-5625	3879.3±109.5	1875-5625	2891.9± 86.5
Folacin (mcg)	252.3 ± 6.2	400	261.9± 9.0#	400	243.7± 8.6#
Zinc (mg)	11.0 ± 0.5	15	11.7± 0.4#	15	10.4± 0.9#

[a]American Heart Association recommendation: <100 mg cholesterol/1000 kcal with an upper limit of 300 mg/day.
[b]MRDAs are not available and therefore Safe and Adequate Estimations are used as the standard.
#Indicates inadequate intake (i.e.. nutrient intake is below the MRDA) for this nutrient.

Table 29. Mean nutrient intake by study groups

VARIABLE	GROUPS			
	ARMYADE	CONTROL	PLACEBO	NBC SOLUTION
Energy (kcal)	2800 ± 108	2512 ± 98.7	2733 ± 82	2703 ± 89
Protein (g)	99.7 ± 5.0	93.9 ± 5.6	108.5 ± 3.8	89.4 ± 3.5
Carbohydrate (g)	390.0 ± 15.3	328.0 ± 12.6	344.9 ± 12.1	388.4 ± 13.2
Fat (g)	96.5 ± 4.6	93.5 ± 4.4	104.6 ± 3.7	89.7 ± 3.6
Cholesterol (mg)	529.0 ± 29.7	511.5 ± 32.5	573.0 ± 32.1	470.2 ± 25.0
Thiamin (mg)	2.3 ± 0.1	2.1 ± 0.1	2.5 ± 0.1	2.2 ± 0.1
Riboflavin (mg)	2.4 ± 0.1	2.2 ± 0.1	2.6 ± 0.1	2.2 ± 0.1
Niacin (mg NE)	25.7 ± 1.3	23.9 ± 1.3	27.7 ± 1.2	23.3 ± 1.0
Vitamin C (mg)	173.2 ± 15.3	171.9 ± 11.0	185.0 ± 17.1	155.0 ± 12.6
Vitamin B_6 (mg)	2.0 ± 0.1	1.8 ± 0.1	2.1 ± 0.1	1.8 ± 0.1
Vitamin B_{12}	4.2 ± 0.3	3.8 ± 0.3	4.4 ± 0.3	3.4 ± 0.2
Vitamin A (mg)	1012.9 ± 64.4	996.5 ± 62.5	1108.0 ± 79.2	910.1 ± 55.0
Iron (mg)	16.7 ± 0.7	16.1 ± 0.8	18.1 ± 0.8	14.6 ± 0.5
Calcium (mg)	1149.3 ± 66.9	1255.7 ± 62.3	1449.0 ± 57.2	1071.8 ± 41.8
Magnesium (mg)	511.0 ± 25.8	283.2 ± 12.3	322.1 ± 11.6	277.6 ± 10.2
Phosphorous (mg)	2010.2 ± 91.7	1541.2 ± 76.4	1735.5 ± 56.3	1703.5 ± 56.2
Sodium (mg)	4537.7 ± 196.6	3393.0 ± 147.3	4217.0 ± 149.8	4764.5 ± 188.6
Potassium (mg)	3913.4 ± 181.8	3050.2 ± 135.9	3576.7 ± 130.1	3047.1 ± 115.4
Folacin (mcg)	276.8 ± 13.5	246.0 ± 12.8	281.2 ± 14.4	218.4 ± 8.9
Zinc (mg)	10.9 ± 0.6	10.5 ± 0.7	11.0 ± 0.4	11.6 ± 1.6

Values are mean±1SEM.

Another reason for the low intake could be that about 26% of the subjects were attempting to lose weight while only 1 subject was attempting to gain weight as reported in the final questionnaire (Table 6). The subjects were very close to equilibrium in their energy intake and expenditure since the mean weight loss for all 4 groups was less than 1 kg (Table 30). This group of subjects may not have needed excessive calories because they started with moderate activity (with spurts of heavy activity) during the first 3 to 4 days while setting up the hospital area but their activity level decreased markedly during the later days while they waited for events to occur in the FTX.

Table 30. Body weight changes from arrival at site (Day 0 PM) to the last afternoon (Day 8 PM).

	GROUPS				
	ARMYADE	CONTROL	PLACEBO	NBC	MEAN
Day0PM	68.6±3.1	78.5±4.2	75.0±4.1	78.9±3.7	75.6±2.0
Day8PM	67.8±3.2	77.7±4.1	74.4±4.2	78.0±3.6	74.8±1.4
Differ	0.8	0.8	0.6	0.9	0.8
p	0.01	0.05	NS	0.01	0.001
n	14	17	12	18	61

The greatest caloric intake matched the days of highest caloric expenditure. The subjects were fairly active setting up the hospital during the first 3-4 days. After the 5th day, they were put on 12 hour work schedules which were fatiguing, but

their physical activity was reduced. A small number of the subjects were sleeping during the day and working at night which reduced their total activity and exposure to the heat stress.

The energy supplied by the test beverages did not significantly affect the energy intakes of the four groups ($F(1,51)=0.42$, $p=0.74$). The calories supplied by the two carbohydrate-electrolyte beverages did not affect the consumption of other foods and fluids. The mean difference in calories supplied by the test beverages ranged from 0 to a maximum of 322 kcal/day. The subjects drinking the NBC and Armyade beverages had consistently higher energy intakes from fluids (NS) (Appendix L) but the difference was probably offset by the wide variations in caloric intake from food.

Potassium and Sodium Intake

No significant differences existed between the groups ($F(3,51)=2.22$, $p=0.10$) for potassium intake but the 2-way ANOVA showed a significant decrease in potassium intake ($F(7,45)=10.95$, $p<0.001$) over the eight days (Table 31). There was no interaction between groups and time ($F(21,129.77)=1.44$ $p=0.10$). On day 4, the potassium intake for the Control group was significantly less than for the Placebo group even though both groups were drinking beverages (water and placebo) that did not contain potassium. Most of the potassium for the Placebo group came from food sources. The intake of potassium for the Control group was consistently (NS) less than for the Armyade and Placebo groups. The mean intake of potassium for all soldiers, 3359±73 mg/day, was well within the range 1875-5625 mg/day that was set for safe and adequate intake in the MRDA (81). Armyade was supplemented with 9 mEq/L of potassium and the intake of potassium for this group was higher than for the other groups (NS). One concern in using potassium supplements

Table 31. Potassium Intake (mg/day).

DAY	GROUPS				
	ARMYADE (n=13)	CONTROL (n=15)	PLACEBO (n=11)	NBC (n=16)	MEAN (n=55)
1	3862±438	3447±455	3829±405	3304±295	3580±197
2	4450±403	3445±407	4282±441	3379±314	3831±199
3	5373±590	3767±484	3715±312	3475±298	4051±236
4	3648±431	2725±252	4196±307	3530±425	3472±193
5	3240±481	2957±321	3319±352	2911±191	3083±166
6	4232±596	2711±358	3390±298	2909±425	3264±228
7	3145±521	2218±341	2792±277	2214±281	2551±186
8	3358±443	3132±335	3092±382	2653±228	3038±171
$\bar{x}$±SE	3913±182	3050±136	3577±130	3047±115	3359±73

is ingestion of toxic amounts. The maximum mean intake of potassium was 5373±590 mg/day on Day 3 for the Armyade group but this level is within the range for safe and adequate intake according to AR 40-25. However, the maximum intake of potassium for an individual drinking Armyade was 9361±231 mg/day, which is about twice the safe and adequate levels. Of equal concern is the fact that one subject in the Control group, which was drinking plain water as its test beverage, ingested 8293±1176 mg of potassium on Day 1. Such high intakes of potassium for the average soldier could lead to concerns about toxicity from drinking potassium-supplemented fluids, but serious problems are usually restricted to humans with impaired kidney function.

Sodium intake was significantly different between groups ($F(3,51)=3.58$, $p<0.05$) and over time ($F(7,45)=4.50$, $p<0.001$) but the interaction between group and time was not significant ($F(21,129.77)=1.04$, $p=0.41$). The subjects in the Control (water) group ingested significantly less ($p<0.05$) sodium than the subjects in the

NBC group on Days 1, 2, and 4 and less than those drinking Armyade on Day 7 (Figure 9). The Armyade and NBC Solutions were supplemented with similar amounts of sodium and the intakes by subjects in those groups were generally higher than for the Control and Placebo groups, but the amount of sodium ingested by the subjects drinking Armyade was not significantly greater than those in the unsupplemented Placebo and Control groups. The exception was Day 7 for the Control group, but was due more to a decrease in sodium intake by the Control group, rather than an increase in sodium intake by the subjects in the Armyade group. On the average the mean sodium intakes were well below the upper limit of the MRDA (5500 mg/day) for all 4 groups and for all 8 days (Appendix M). As with potassium intake, there were subjects that ingested excessively large amounts of sodium. Four subjects in the Control and NBC groups consumed over 10,000 mg of sodium in one day. Sweat and urine losses helped to rid the body of some of this sodium. A soldier sweating about 1/2 L/hr for 24 hours (moderate work at 70°F WBGT) could lose 11,040-16,560 mg of sodium per day in sweat. Hard physical work in a hot environment could cause sodium losses as high as 8000 mg/day (37); however, soldiers in the present study were not working that hard.

Macronutrient, Vitamin, and Mineral Intakes

The mean intakes for males met the MRDA for energy, protein, vitamins, and minerals except vitamin B_6, folacin, and zinc (Table 28). The females had inadequate intakes (i.e., nutrient intakes below the MRDA) of iron and magnesium in addition to those mentioned for males. However, the data for Vitamin B_6, folacin, and zinc may be underestimated due to missing data in the nutrient data file and therefore these values should not be interpreted to mean that intakes were deficient.

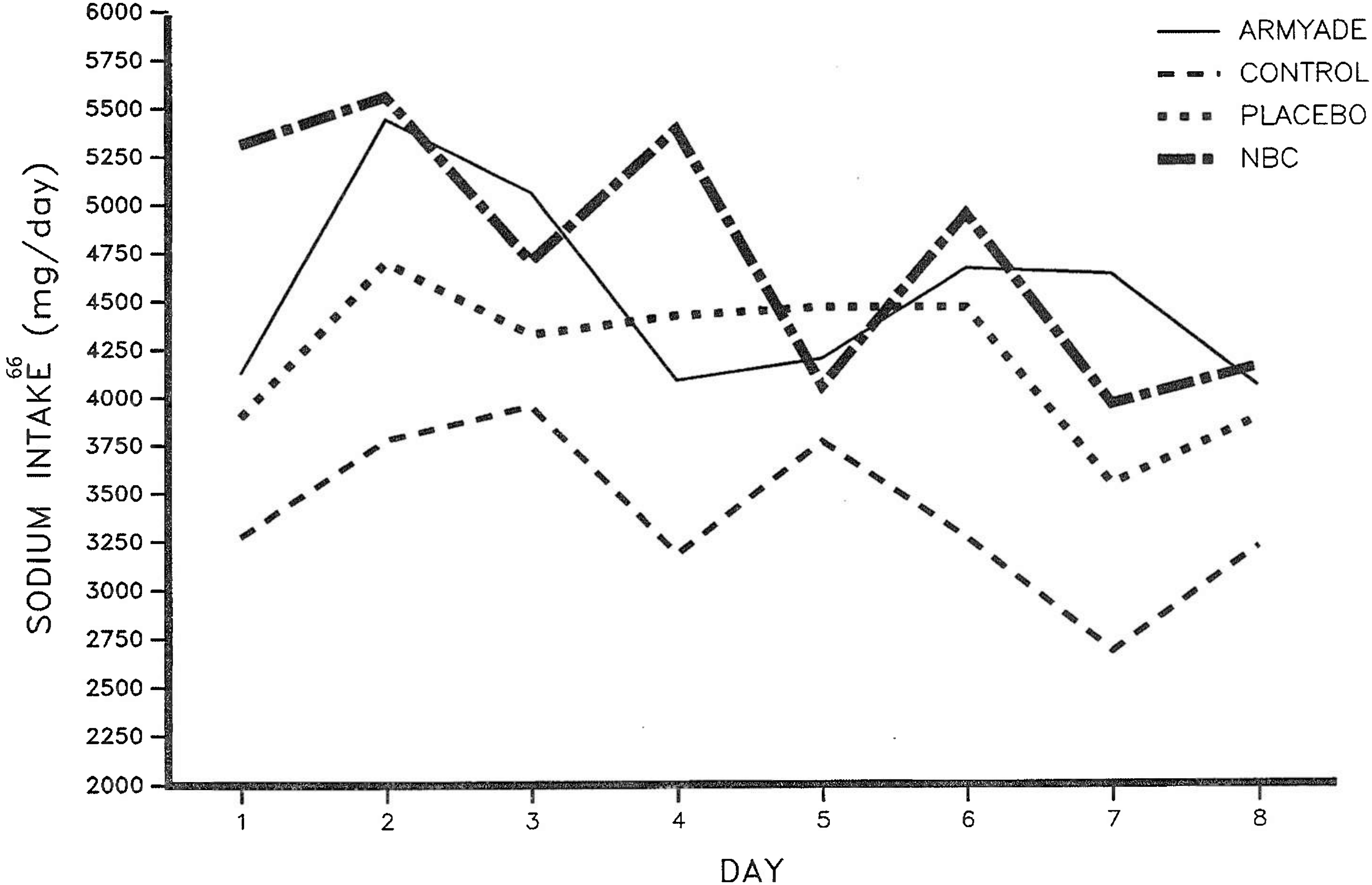


Figure 9. Sodium intake during 8 days of field exercises in the heat.

NUTRITIONAL INTAKE

The mean intake values for males for all nutrients is comparable to other garrison dining facility (83-85) and field (46,64) studies. The group drinking Armyade, which was supplemented with Mg^{++}, ingested 128-170% of the MRDA for males and females for Mg^{++} but dividing the data by group showed that intakes were inadequate for almost all of the other test beverage groups (Table 29). Females have always had problems meeting the MRDA for iron and eating in the field is no different especially when the MREs, which contain about 8 mg of iron, are not eaten for lunch.

For the pooled subjects, the mean carbohydrate intake was within the 50-55% of energy intake guidelines suggested in AR 40-25 (Table 28). The NBC and Armyade solutions contained fructose and glucose polymers, respectively, whereas the placebo and water did not contain any carbohydrates. However, there were no significant differences in carbohydrate intake between the groups (Table 29). The mean protein intakes for males and females met the MRDA. The value for fat intake for the pooled subjects (Table 28) was excellent at 32% because it was less than the 35% recommended by the 1985 MRDAs. Previous studies showed that soldiers were eating more than 35% fat in their diet in garrison and in the field (46,64,83,84) except for the basic trainees at Fort Jackson, SC (85). The cholesterol intake of 581±22 mg for males in the present study was much lower than the 677-761 mg of previous garrison dining facility and field studies (46,83,84,85).

The average pooled data showed that the subjects in the present study consumed 85% of the MRDA for Mg^{++}, 77% for Na^{+}, 60% for K^{+}, and 145% for phosphorus from their diets and all fluids including the test beverages (Table 28). The maximum amount of Armyade that was consumed was 7200 ml/24 hours which would provide the following percentages of the MRDA (81): 114% for Mg^{++}, 69%

for Na^{+}, 47% for K^{+}, and 59% for phosphorus. Due to the supplementation of Armyade with Mg^{++}, the intake of Mg^{++} was almost twice as high in the group drinking Armyade as in the other groups. Consumption of Armyade in these quantities should not cause any toxicity problems especially since about half of the electrolytes that Armyade provided was probably lost in an equal amount of sweat (Table 2). Since Armyade contains 22.8 mEq/L of sodium, consumption of Armyade could contribute to hypernatremia resulting from dehydration. However, while hypernatremia can occur as a consequence of mild heat injury, the increase in serum sodium concentration was modest. In addition Armyade is hypotonic (127 mOsm/kg) and therefore the likelihood of hypernatremia occurring was remote. Armyade also contains K^{+} (9.5 mEq/L), Mg^{++} (5.2 mEq/L), and PO_4 (3.2 mEq/L). While hyperkalemia, hypermagnesemia, and hyperphosphatemia can result from hemoconcentration from mild heat injury, these increases would be of a modest nature. Clinically significant increases in serum K^{+}, Mg^{++}, and PO_4 occur usually in the anuric subject with acute renal failure. Identification and discontinuation of Armyade consumption by anuric subjects was insured by the requirement for twice daily urine samples by all study subjects. The consumption of Armyade in the present study did not appear to present a hazard to subjects consuming this solution.

HYDRATION STATUS

METHODS

The method for collecting urine and body weight data is discussed in the General Methods Section. Urine data were statistically analyzed by two-way ANOVA with repeated measures to determine significances and Tukey's post hoc tests were run to establish where the differences occurred. Calculated values were generated for a subject's database when a urine sample or body weight measurement was unavailable. Because drinking behavior and therefore, hydration status is variable among adults (86), frequency distributions which describe the incidence of urine specific gravities $\geq$ 1.030 provide a better characterization of hypohydration of a group than the average group values. The calculated values were not used when generating frequency distributions. A chi-square was computed to establish whether the incidence of urine specific gravity $\geq$1.030 and group was related. Urine specific gravity measurements $\geq$1.030 and body weight losses $\geq$3% were used as criteria to define hypohydration. Appendix N contains the mean data for the figures in this section.

RESULTS AND DISCUSSION

Generally, urinary specific gravity displayed a diurnal periodicity, with higher recordings in the morning (AM) sample compared to the late afternoon (PM) sample. The data indicated a trend toward increasing urinary specific gravity with elevated wet bulb globe temperature (WBGT). A reduction in heat load due to reductions in both ambient conditions and work intensity on Day 5 was accompanied by a decline in group averages of urinary specific gravity.

Group means for urine specific gravity (Figure 10) were significantly higher at collections 2AM, 2PM, 5AM, and 7AM when either Armyade or Control (plain water) was consumed compared to those measured in the Placebo and NBC groups.

Increases in urinary specific gravity can reflect hypohydration, impending hypohydration or renal adaptations preventing significant hypohydration, and can therefore be used as an index of hydration status. None of the groups displayed an average urinary specific gravity greater than 1.030 at any sampling time. This was surprising because many of the volunteers were erecting tents for the field hospital from about 0800-2000 hrs during the first five days. On day 4, work continued despite oppressive ambient conditions (d.b.max = 101°F, WBGTmax = 90.3°F).

Significant differences ($p<0.05$) in the incidence of urinary specific gravity equal to or greater than 1.030 during the eight days of the field exercise were found among the four groups. While 8% of urine samples collected from soldiers consuming the placebo and 6% of those from individuals assigned to the NBC solution had specific gravities $\geq$1.030 during the eight test days (Table 32), 13% and 22% of the urine samples collected from the soldiers drinking Armyade and plain water (Control group), respectively, had specific gravities $\geq$1.030. Based on the Chi-square test, the relationship between group and the incidence of urine specific gravity

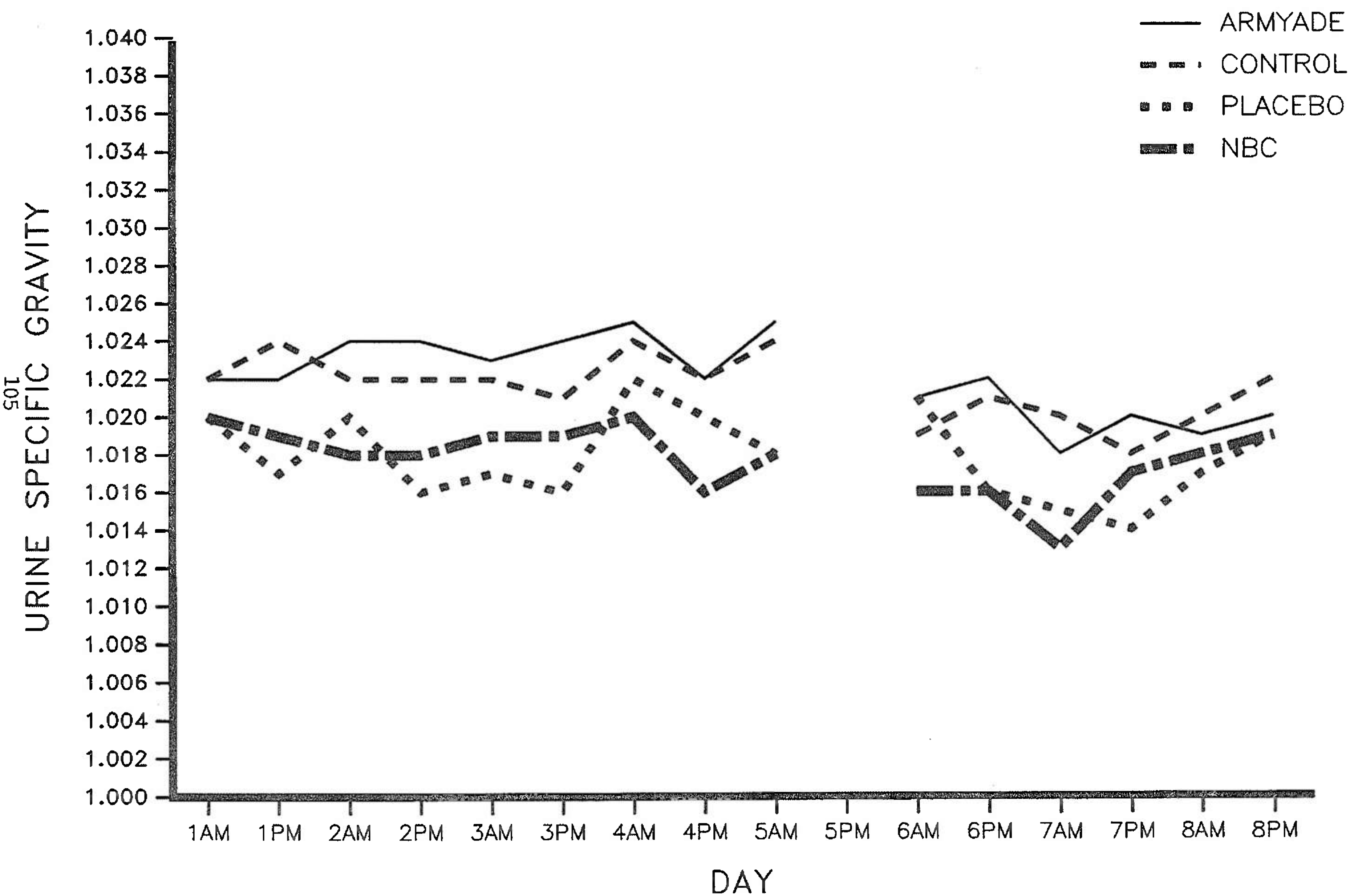


Figure 10. Diurnal urine specific gravity measurements during 8 days in the heat.

Table 32. Percent of individuals with urine specific gravity $\geq$1.030

GROUP	% OF INDIVIDUALS
ARMYADE	13
CONTROL	22
PLACEBO	8
NBC	6

Percents are calculated from the number of man-observations in each group over the course of the eight test days.

$\geq$1.030 is significant.

Figures 11-14 depict the incidence of urine specific gravity $\geq$1.030 for the eight study days; while significant numbers of individual values were observed to be $\geq$1.030, none of the group means attained this value. Of importance is the observation that the number of urine samples exceeding the criterion for hypohydration differed significantly ($p<0.05$) between groups on Days 1,3 and 4 (Table 33). The incidence of urinary specific gravity $\geq$1.030 in soldiers drinking the Armyade or Control beverage (plain water) peaked on the hottest day (Day 4) and then declined. The reduction in the number of samples exceeding the criterion for hypohydration from Day 4 to Day 5 was surprisingly small, but this may be attributed to the persistently low fluid intake. Although the fluid intake seen after Day 5 did not reach the magnitude of Days 3 and 4, the incidence of high urinary specific gravity decreased. This decrease was most likely due to a combination of the following factors: moderately elevated drinking, reduced environmental heat stress, and lessened work load. In comparison, urine samples having specific gravities $\geq$1.030 from soldiers consuming either the placebo or the NBC solution

Figure 11. Incidence of urine specific gravity ≥1.030 for the Armyade group.

Subject	DAY 1 AM	DAY 1 PM	DAY 2 AM	DAY 2 PM	DAY 3 AM	DAY 3 PM	DAY 4 AM	DAY 4 PM	DAY 5 AM	DAY 6 AM	DAY 6 PM	DAY 7 AM	DAY 7 PM	DAY 8 AM	DAY 8 PM
n=	14	14	13	14	14	12	14	13	13	13	12	14	13	14	14
A03															
A04															
A06					X		X	X	X						
A08							X		X						
A09															
A10						X		X							
A11								X	X	X	X				X
A12			X												
A13	X		X			X									
A14															
A17					X		X	X	X		X				
A19							X	X		X					
A20															
A21															

Figure 12. Incidence of urine specific gravity ≥1.030 for the Control (water) group.

Subject	DAY 1 AM	DAY 1 PM	DAY 2 AM	DAY 2 PM	DAY 3 AM	DAY 3 PM	DAY 4 AM	DAY 4 PM	DAY 5 AM	DAY 6 AM	DAY 6 PM	DAY 7 AM	DAY 7 PM	DAY 8 AM	DAY 8 PM
n=	16	16	16	17	17	16	17	15	16	16	14	14	15	14	14
B01		X		X	X		X		X	X	X	X	X	X	
B03															
B04															
B05								X							
B07															
B08	X	X		X	X	X		X	X						X
B10		X		X											
B13						X									
B15								X			X	X			
B16	X	X					X	X	X	X	X				
B17															
B18															
B19	X	X	X	X	X	X	X	X	X						
B20	X		X	X	X	X	X								
B21	X	X													
B22		X					X	X	X						
B23															

Figure 13. Incidence of urine specific gravity $\geq$1.030 for the Placebo group.

Subject	DAY 1		DAY 2		DAY 3		DAY 4		DAY 5	DAY 6		DAY 7		DAY 8	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	AM	PM	AM	PM	AM	PM
n=	12	12	12	12	12	12	12	12	12	12	12	12	11	11	11
C01		X	X					X							
C02															
C03															
C04															
C06		X		X							X				
C07		X	X									X		X	
C10										X	X				
C13								X							
C14															X
C15															
C16															
C17															

Figure 14. Incidence of urine specific gravity $\geq$1.030 for the NBC group.

Subject	DAY 1		DAY 2		DAY 3		DAY 4		DAY 5	DAY 6		DAY 7		DAY 8	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	AM	PM	AM	PM	AM	PM
n=	18	18	18	18	17	18	18	17	17	18	15	16	16	16	17
D01															
D02															
D03															
D04															
D05									X	X				X	
D06		X													X
D07															
D08															
D10															
D12															
D13			X												
D14															
D16					X	X			X	X					
D17															
D18															
D19		X		X		X									
D21				X		X									
D23															

Table 33. Frequency (%) of urine specific gravity $\geq$1.030 for Days 1 to 8.

GROUP	DAY							
	1*	2	3*	4*	5	6	7	8
ARMYADE	4	11	19	33	31	16	4	4
CONTROL	31	21	30	34	31	17	11	7
PLACEBO	12.5	12.5	0	8	0	12.5	4	9
NBC	5.5	8	11	0	12	6	0	6

$$\text{FREQUENCY (\%)} = \frac{\text{number of samples with specific gravity} > 1.030}{\text{total number of samples}} * 100$$

* Indicates significant relationship between group and urine specific gravity $\geq$ 1.030.

were consistently fewer in number.

Urinary excretion of sodium is depicted in Figure 15 and generally indicates that both groups consuming the electrolyte-supplemented beverages, Armyade and NBC solution, manifested the highest levels of sodium excretion. On Day 1 PM, the group consuming Armyade excreted more sodium than all other groups ($p<0.01$), and at the same sampling time on Day 2, this group manifested greater sodium excretion than either the Control group (drinking water) ($p<0.05$) or placebo ($p<0.01$). If Figure 15 is compared with Figure 9 (mean sodium intake by day), it is interesting to note that sodium excretion tracks sodium intake quite closely. Therefore, it appears that the subjects were receiving enough sodium in their diet and were excreting excesses from the carbohydrate-electrolyte beverages.

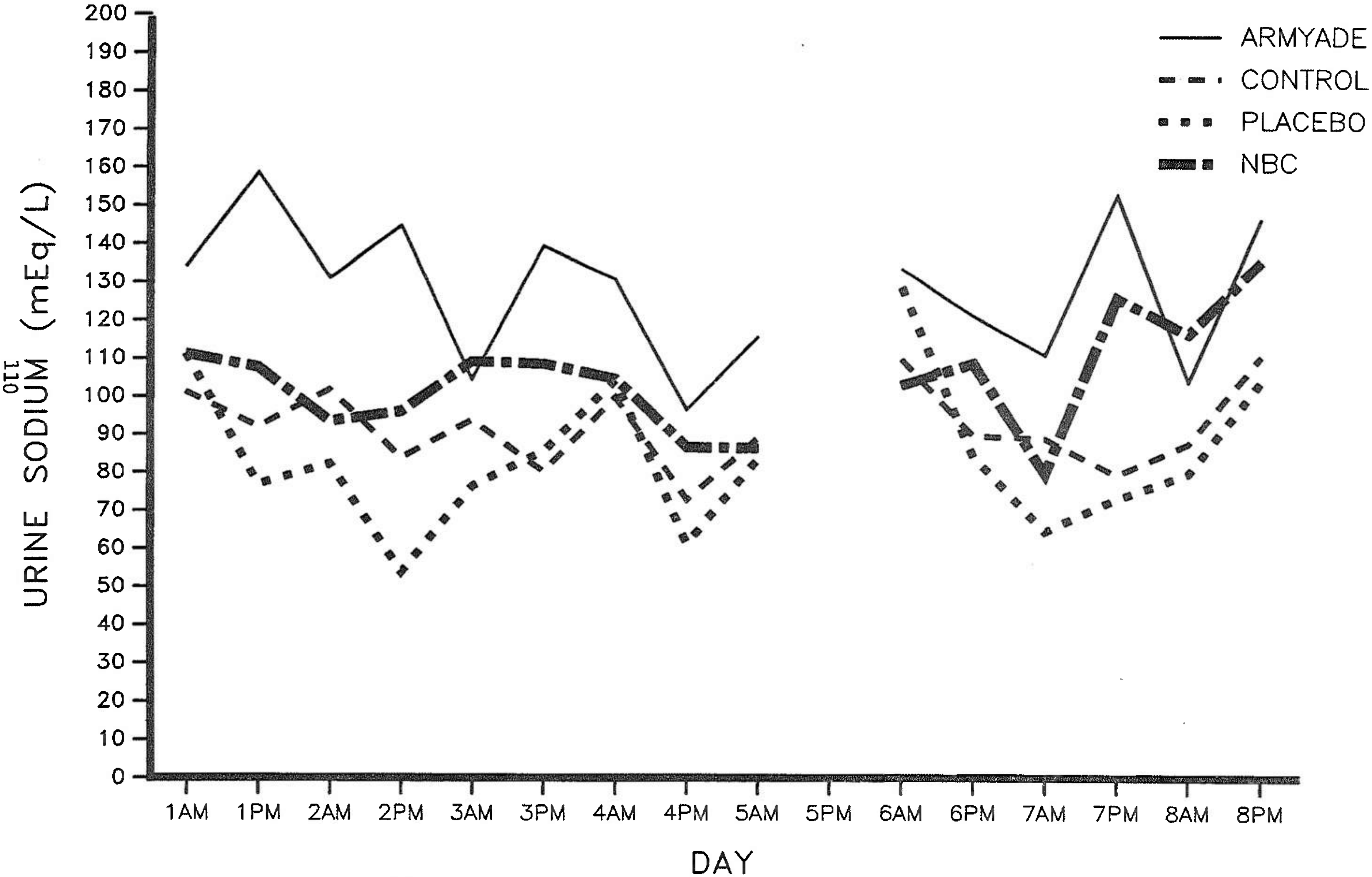


Figure 15. Effects of consumption of carbohydrate–electrolyte beverages and controls on diurnal excretion of sodium.

It should also be noted that urinary sodium excretion will also be affected by level of acclimation, sweat secretion, and hydrational status, all of which could have contributed to the inconsistency of data at specific sampling times (e.g. Day 4 AM and PM, p=NS, all groups).

Data depicted in Figure 15 indicate again that dietary consumption of electrolytes is the most critical factor determining urinary excretion levels. Comparison of the data depicted in Figure 16 and Table 31 provide several interesting observations. The Armyade group had the highest level of potassium consumption (Table 31, 3913 mg/d) and clearly manifested the greatest potassium excretion (Figure 16). Similarly, the placebo group (3577 mg/d) consumed more potassium than both groups drinking Control beverage (water) and NBC solution (3050 mg/d), and Figure 16 demonstrates generally that the placebo group excreted consistently more potassium than either the Control or NBC groups during the first four days of the scenario. On days 6,7, and 8, the only statistically significant difference among groups was observed on Day 6 PM where subjects drinking Armyade excreted significantly ($p<0.01$) more potassium than individuals consuming NBC solution.

Occasionally, urinary sodium/potassium ratios have been used as an approximation of hydrational status (67) since, during hypohydration, hormones which promote sodium reabsorption and potassium excretion are ordinarily secreted. Such an endocrinological adaptation then would tend to decrease urinary sodium/potassium ratios during hypohydration. The data depicted in Figure 17 generally indicate no consistent trends in these calculated values. The significantly increased mean values of this ratio calculated for the NBC group (e.g. Day 3, PM, NBC group > Control (water) group, $p<0.05$; Day 6, PM, NBC group > Armyade,

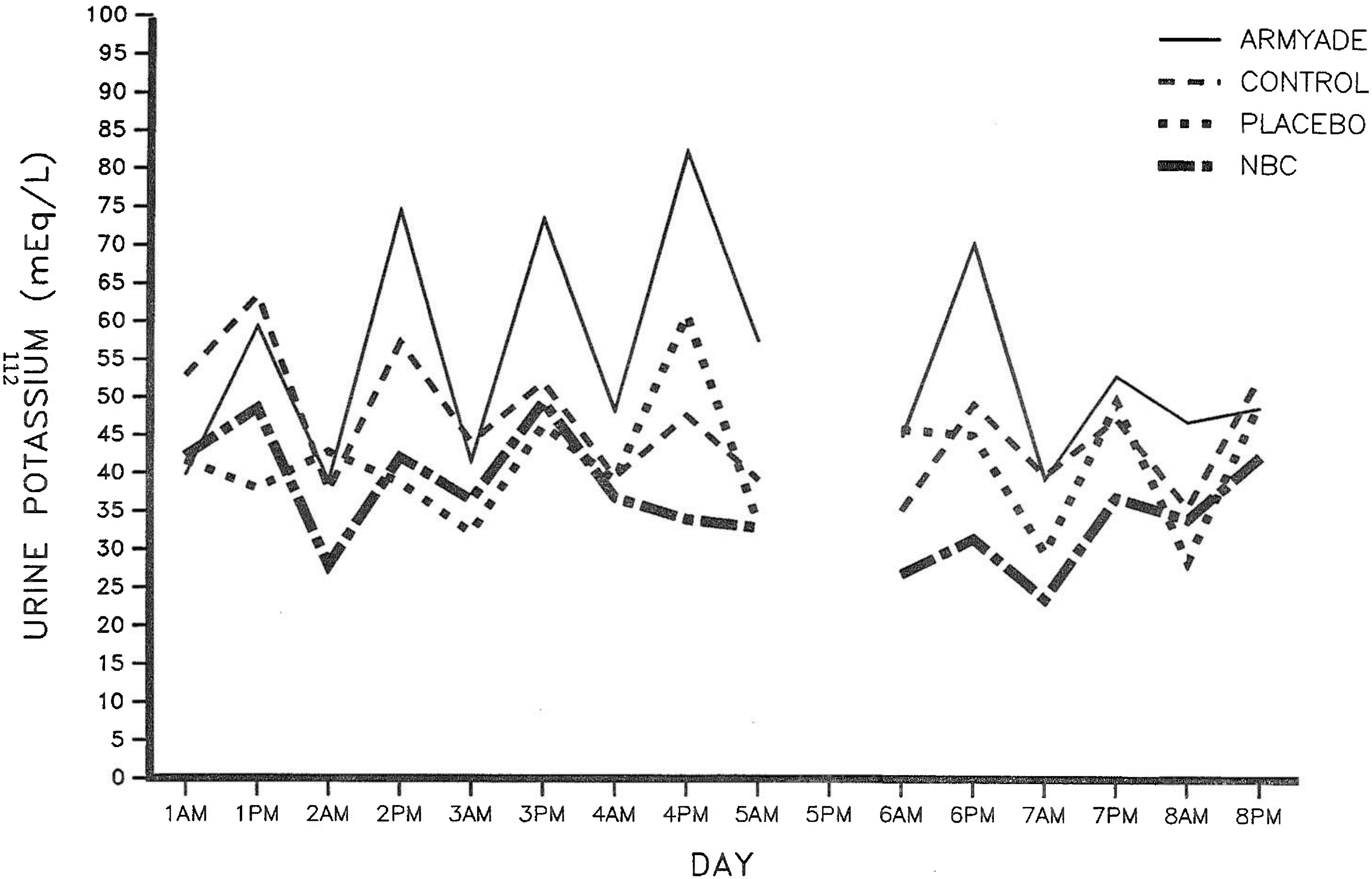


Figure 16. Effects of consumption of carbohydrate-electrolyte beverages on diurnal urinary excretion of potassium.

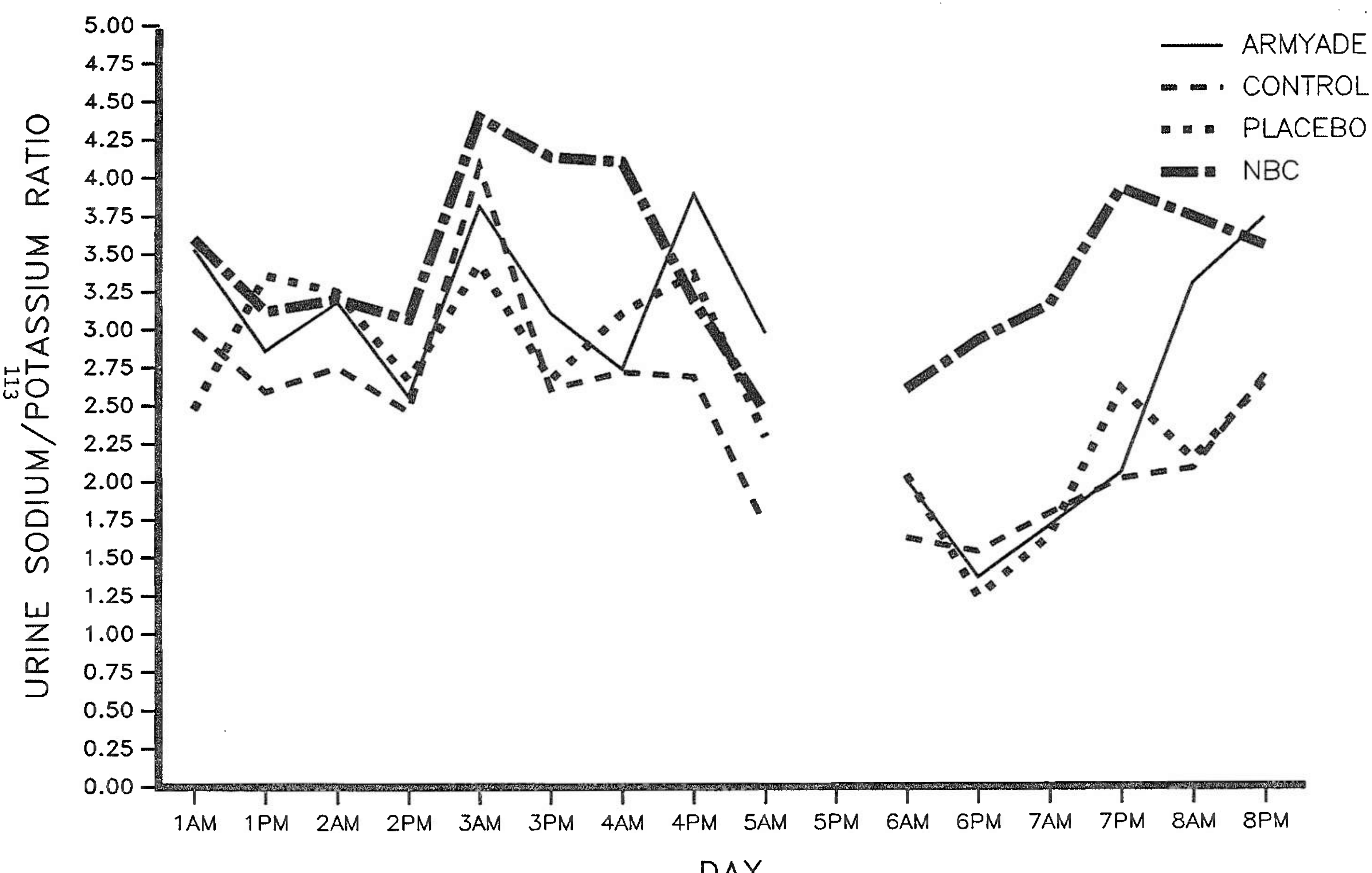


Figure 17. Diurnal urinary sodium to potassium ratios as indicators of hydration.

Control (water) and placebo groups $p<0.01$; Day 7, AM, NBC group > Armyade, Control (water) and placebo groups $p<0.01$)) are probably reflective of the fact that in the NBC solution the ratio of sodium to potassium is extremely high while in the Armyade solution this ratio is reduced to 2.

Ordinarily, urinary specific gravity is closely correlated with urinary creatinine concentration and both are usually inversely correlated with urinary volume. Thus, it is interesting to note (Figure 18) that on Day 5 AM, the creatinine concentration of the Armyade group is significantly greater than that of the Placebo group ($p<0.05$); at this particular sampling time the Armyade group had four subjects with urinary specific gravity $\geq$1.030 while the Placebo group had none.

The blood urea nitrogen (BUN), serum creatinine, and BUN/Creatinine ratios measured on Day 0 and Day 8 are within the normal range (65) reported for each parameter in Table 34 in the Biochemical Indices Section. Although statistically significant, the fall in the BUN/Creatinine ratio from Day 0 to Day 8 in the soldiers in the Control (water) group is within normal values. Because we have previously observed an increase in this ratio with progressive dehydration (67), this fall was unexpected. However, it may be explained in part by the high incidence of urine specific gravity $\geq$1.030 on Day 0 (5/29) which peaked on Day 4 (11/32) and fell by Day 8 (2/28). Unfortunately, blood samples were not available on Day 4, and thus no assessment of these variables could be made on the day of apparently maximal hypohydration.

These data indicate that electrolyte ingestion was remarkably mirrored in urinary excretion. Generally, the intake of sodium from both the Armyade and NBC supplements was reflected in the urinary concentration of this electrolyte in the urine specimens of these two Groups. Likewise, the increased potassium of the

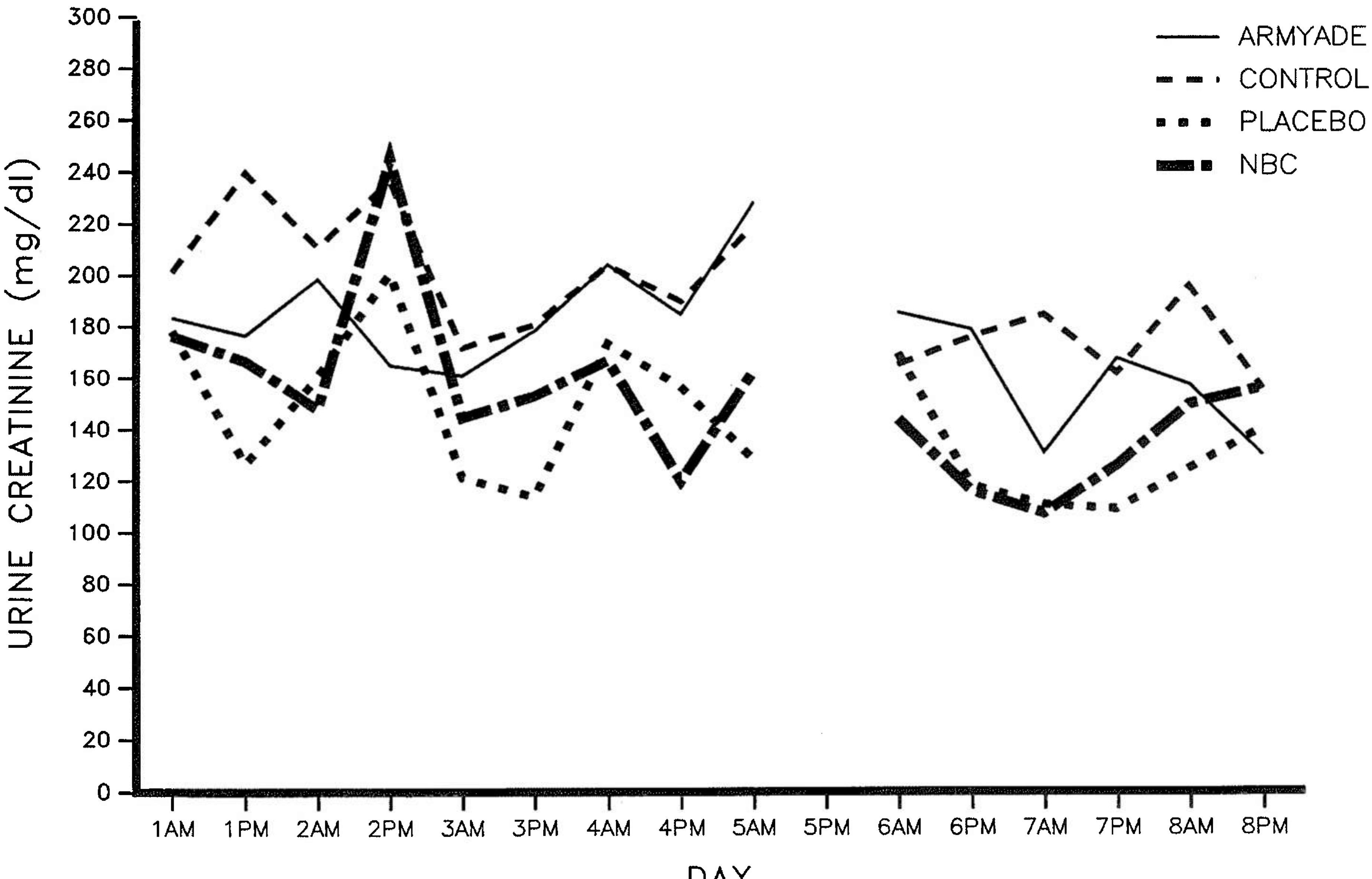


Figure 18. Urinary creatinine excretion as indicators of hydration.

Armyade relative to the NBC solution was reflected in the potassium excretion of this group, and contributed to the increased urinary sodium/potassium ratios of the NBC group versus the Armyade group. Therefore, under conditions of light to moderate activity where meals are eaten, consumption of water or non-nutritive flavored beverages are adequate to maintain electrolyte homeostasis.

The other criterion of hypohydration was body weight. Figure 19 shows that group averages for body weight were virtually unchanged for the eight days. Differences between groups were not statistically significant. The change in body weight measured during the work day (0700 - 1600 hrs) is shown for the four groups in Figure 20. No group average exceeded the $\geq$3% body weight loss criterion during the work day. Generally, the pattern was similar for all groups. and actually represented a weight gain during the work day. Surprisingly, the weight gain occurred when the intensity of both work and environmental heat stress was greatest. Increases in weight accrued during the 8 hr work day, increased during the first four days of the exercise, and then fell after day 6. The greatest gains were observed on Days 2, 3, and 4 in the group assigned the Placebo as the test beverage, but no statistically significant differences were noted between groups on any day. This pattern in weight change of the group averages followed the changes seen in group means for fluid intake (Table 17). The percent change in body weight (Figure 21) normalizes body weight changes to the pre-deployment weight. The cumulative percent change in body weight was not different among the four groups; group averages did not exceed the 3% criteria, and displayed a diurnal pattern.

The number of soldiers attempting to lose weight during this field exercise was lower than that seen during a previous study in 1985 (64) in which 31% of the

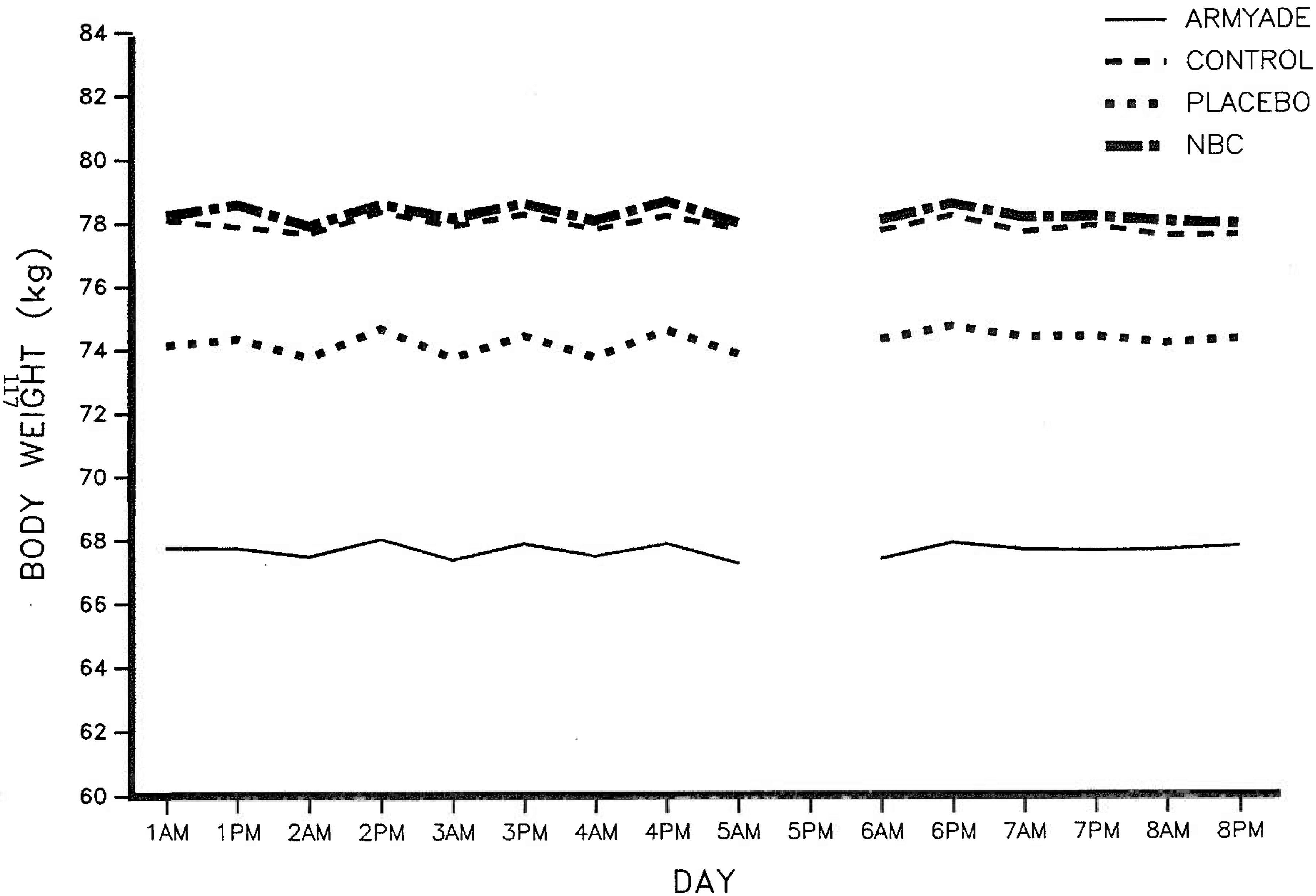


Figure 19. Body weight changes during 8 days of work in the heat.

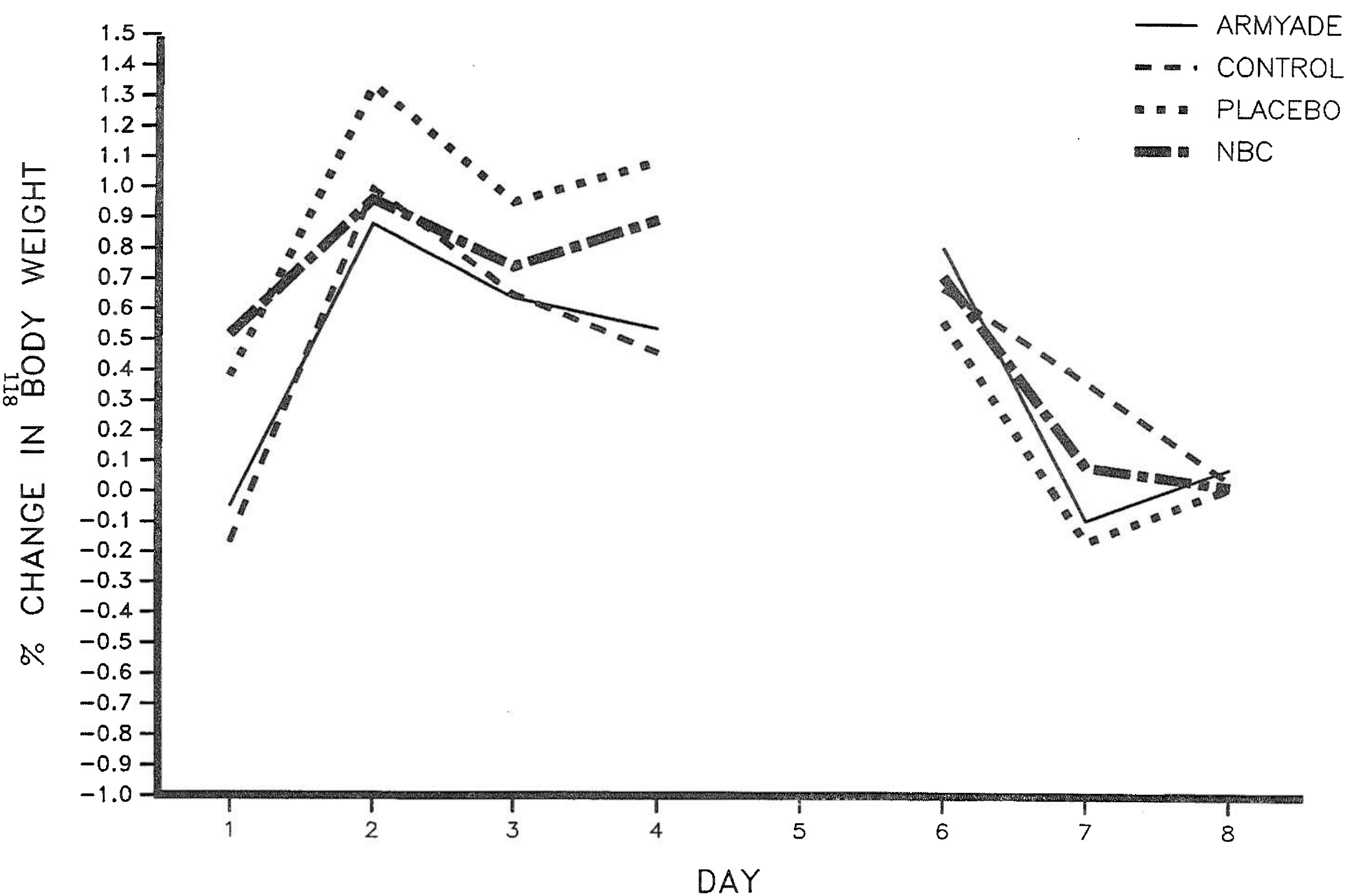


Figure 20. Percent change in body weight during the work day (0700–1600 hrs).

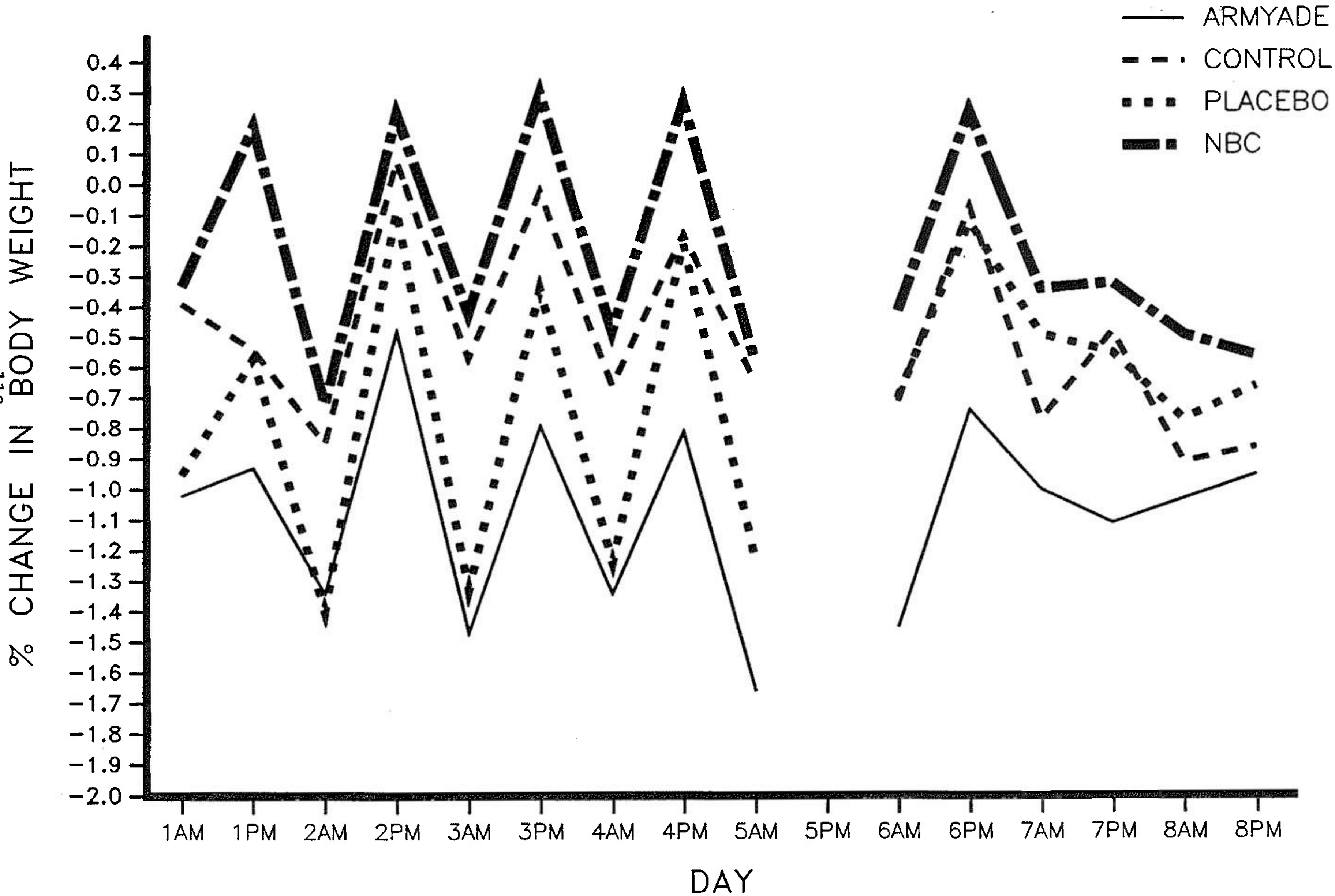


Figure 21. Percent change in body weight from pre-deployment.

males and 86% of the females reported trying to reduce weight. In the current study, demographic data collected on Day 9 indicated that only 26% of the subjects were attempting to lose body weight. Of the eight females attempting weight loss, a loss was recorded in six subjects and a small weight gain was observed in the remaining two. The six males attempting to lose weight were equally divided in weight loss and weight gain. Although body weight loss provides an accurate index of hypohydration level in a laboratory setting, the impact and variations in environmental conditions reduces its reliability as a measure of hydration status in a long term field environment.

Sohar and associates (62) reported that even mild dehydration causes drowsiness, impatience, discomfort, weariness, irritability, and reduces work efficiency. Because we collected data twice daily from our subjects, we had an opportunity to witness their behavior. On several of the hottest days (Days 1-5) during which physical labor was intense, about eleven of our subjects (A06, A11, A14, A17, A19, B07, B19, B20, D06, D12, D16) displayed symptoms of mild dehydration. Of notable interest is subject B19, who is a young nineteen year old, hard working male. This subject worked daily setting up hospital tents and perimeters as well as being on 12 hour guard duty shifts without shade protection during the hottest portion of the day. On several occasions, B19 displayed symptoms of about 3-5% dehydration including aggressive behavior, impatience, anorexia, headache, and stumbling. This subject had urine specific gravities $\geq$1.030, low urinary sodium to potassium ratios, and high urinary creatinine outputs (270-385 mg/dl) on almost all days and had a loss $\geq$3% from pre-deployment body weight commencing on the Day 6 AM collection. In this particular subject, urine specific gravity was a good indicator of hypohydration or impending hypohydration.

Although urine specific gravity values for individual subjects suggest some hypohydration or impending hypohydration, the group averages for body weight changes concur with the group averages for urine specific gravity and indicate that generally, acute hypohydration was not a problem in any test beverage group during the eight test days. These group data suggest that individuals were eating and drinking sufficient quantities during the work day to maintain weight and hydration status. Our data also indicate that in a population comprised of reservists consuming field rations during field exercise training, fluid intake can be enhanced and consequently, hypohydration can be lessened, by flavoring the field drinking water.

BIOCHEMICAL INDICES

METHODS

The methods for collecting blood, urine, and body weight data are discussed in the General Methods Section and in the preceding Hydration Status Section.

RESULTS AND DISCUSSION

Serum biochemical monitoring included examination of the following twelve clinical chemistries: glucose, sodium (Na^+), potassium (K^+), magnesium (Mg^{++}), blood urea nitrogen (BUN), creatinine (Cr), phosphorus (PO_4), chloride (Cl^-), total protein, albumin, cholesterol, and triglycerides (Table 34). Because dehydration can be accompanied by hypernatremia, hyperkalemia, hyperchloremia, azotemia, and hypercreatininemia, serum Na^+, K^+, Cl^-, BUN, Cr, and BUN/creatinine (BUN/Cr) ratio were closely monitored. In addition, because the Armyade and NBC solution contained carbohydrates (2.5% maltidextrins and 2.5% fructose/maltidextrin, respectively), changes in blood glucose were of interest. Only one of the beverages, Armyade, contained Mg^{++}. This fact dictated the necessity to monitor serum and urine Mg^{++}.

In examining the pooled data for all subjects (Table 34), a statistically significant increase was seen for serum glucose (Figure 22) and magnesium (Figure 23), while statistically significant decreases were seen for serum Na^+ (Figure 24) and cholesterol (Figure 25) when comparisons were made between Day 0 versus Day 8. While those changes were of statistical significance, the values per se were all within the normal range.

Table 34. Serum changes after 8 days of work in the heat.

PARAMETER MEASURED	ALL SUBJECTS	GROUPS ARMYADE	CONTROL	PLACEBO	NBC
Day 0 Glucose (mg/dl)	88 ± 3	84 ± 2	85 ± 5	101 ± 8	83 ± 3
Day 8 Glucose	96 ± 2[b]	94 ± 6	94 ± 4	97 ± 3	100 ± 3[a]
Day 0 Sodium (mEq/L)	142 ± 0	143 ± 1	141 ± 1	143 ± 1	141 ± 1
Day 8 Sodium	139 ± 1[b]	136 ± 4	140 ± 1	141 ± 1[b]	141 ± 1
Day 0 Potassium (mEq/L)	4.4 ± 0.1	4.2 ± 0.1	4.3 ± 0.1	4.6 ± 0.2	4.3 ± 0.1
Day 8 Potassium	4.3 ± 0.1	4.4 ± 0.2	4.2 ± 0.1	4.5 ± 0.1	4.3 ± 0.1
Day 0 Magnesium (mg/dl)	2.12 ± 0.02	2.12 ± 0.40	2.08 ± 0.05	2.19 ± 0.05	2.08 ± 0.04
Day 8 Magnesium	2.20 ± 0.03[a]	2.18 ± 0.06	2.18 ± 0.03[b]	2.19 ± 0.06	2.23 ± 0.05[b]
Day 0 BUN (mg/dl)	14 ± 1	13 ± 1	12 ± 1	17 ± 2	12 ± 1
Day 8 BUN	13 ± 1	13 ± 1	10 ± 1	17 ± 2	13 ± 1
Day 0 Creatinine (mg/dl)	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1
Day 8 Creatinine	1.0 ± 0.0	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1
Day 0 BUN/Cr	14.62 ± 0.72	14.24 ± 0.90	14.48 ± 1.53	17.17 ± 2.09	12.68 ± 0.90
Day 8 BUN/Cr	14.19 ± 0.89	14.07 ± 1.36	10.79 ± 0.69[b]	17.71 ± 2.59	14.23 ± 1.64
Day 0 Chloride (mEq/L)	108 ± 0	109 ± 1	108 ± 1	110 ± 1	107 ± 1
Day 8 Chloride	108 ± 1	105 ± 4	109 ± 1	110 ± 1	109 ± 1
Day 0 Total Protein (g/dl)	7.5 ± 0.1	7.6 ± 0.1	7.4 ± 0.2	7.4 ± 0.2	7.4 ± 0.1
Day 8 Total Protein	7.3 ± 0.1	7.2 ± 0.3	7.2 ± 0.2	7.3 ± 0.2	7.4 ± 0.1

Table 34. Continued

PARAMETER MEASURED	ALL SUBJECTS	GROUPS			
		ARMYADE	CONTROL	PLACEBO	NBC
Day 0 Albumin (g/dl)	4.3 ± 0.1	4.5 ± 0.1	4.3 ± 0.1	4.3 ± 0.1	4.4 ± 0.1
Day 8 Albumin	4.3 ± 0.1	4.2 ± 0.2	4.2 ± 0.1	4.2 ± 0.1	4.5 ± 0.1
Day 0 Cholesterol (mg/dl)	191 ± 5	191 ± 8	190 ± 13	201 ± 10	182 ± 14
Day 8 Cholesterol	176 ±5[a]	175 ± 10	174 ± 12[b]	182 ± 6[b]	172 ± 10
Day 0 Triglyceride (mg/dl)	139 ± 16	115 ± 17	133 ± 21	170 ± 48	137 ± 31
Day 8 Triglyceride	124 ± 13	129 ± 19	96 ± 5	143 ± 43	127 ± 24
Day 0 Phosphorus (mg/dl)	3.96 ± 0.08	4.06 ± 0.17	4.03 ± 0.14	3.85 ± 0.15	3.90 ± 0.20
Day 8 Phosphorus	3.92 ± 0.07	3.85 ± 0.20	3.88 ± 0.09	3.90 ± 0.14	4.06 ± 0.09

All Statistical Comparisons Are Between Day 0 vs Day 8

Values are mean±1SEM

[a] $p < 0.01$

[b] $p < 0.05$

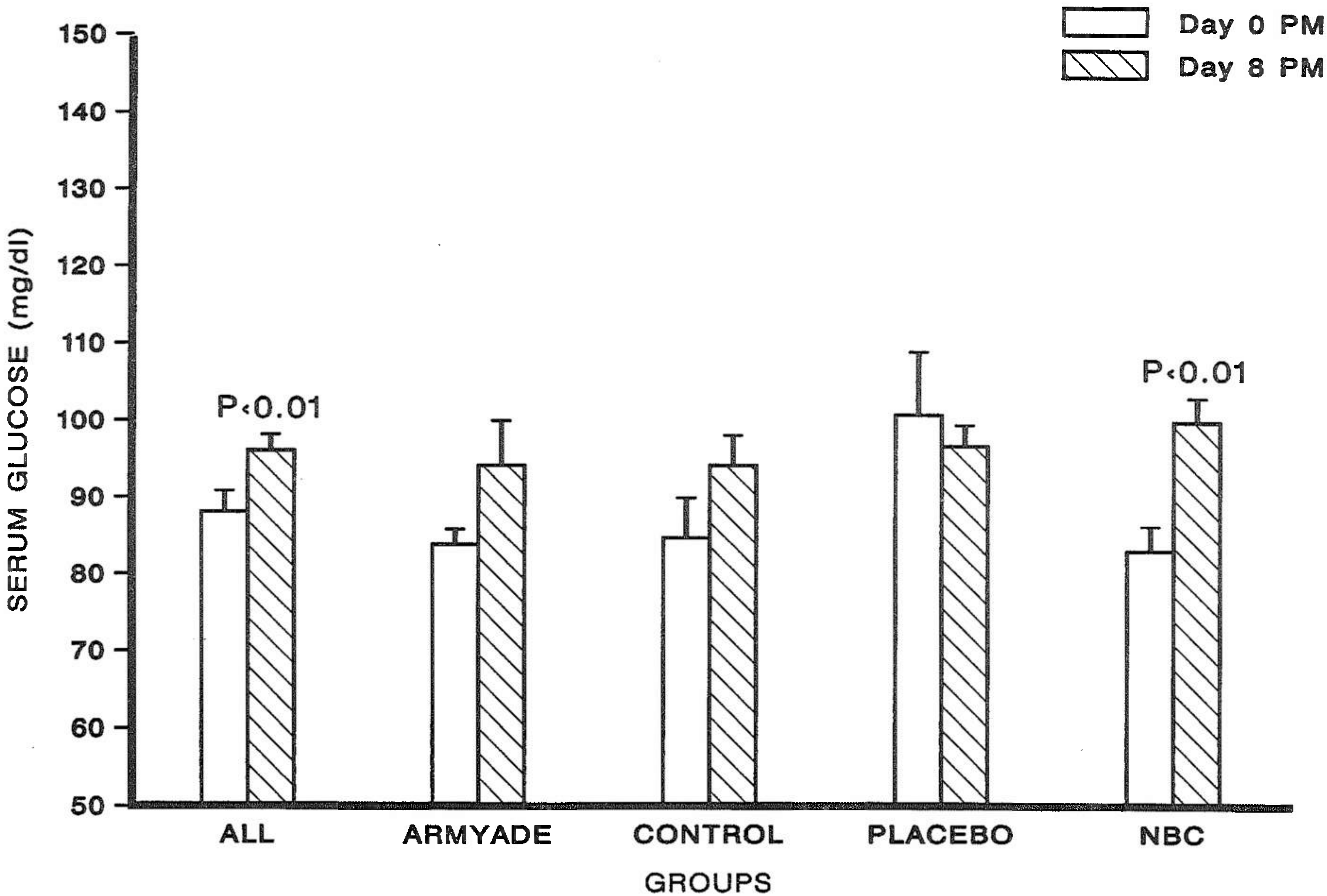


Figure 22. Serum glucose (mean ± SE) before and after 8 days of work in the heat.

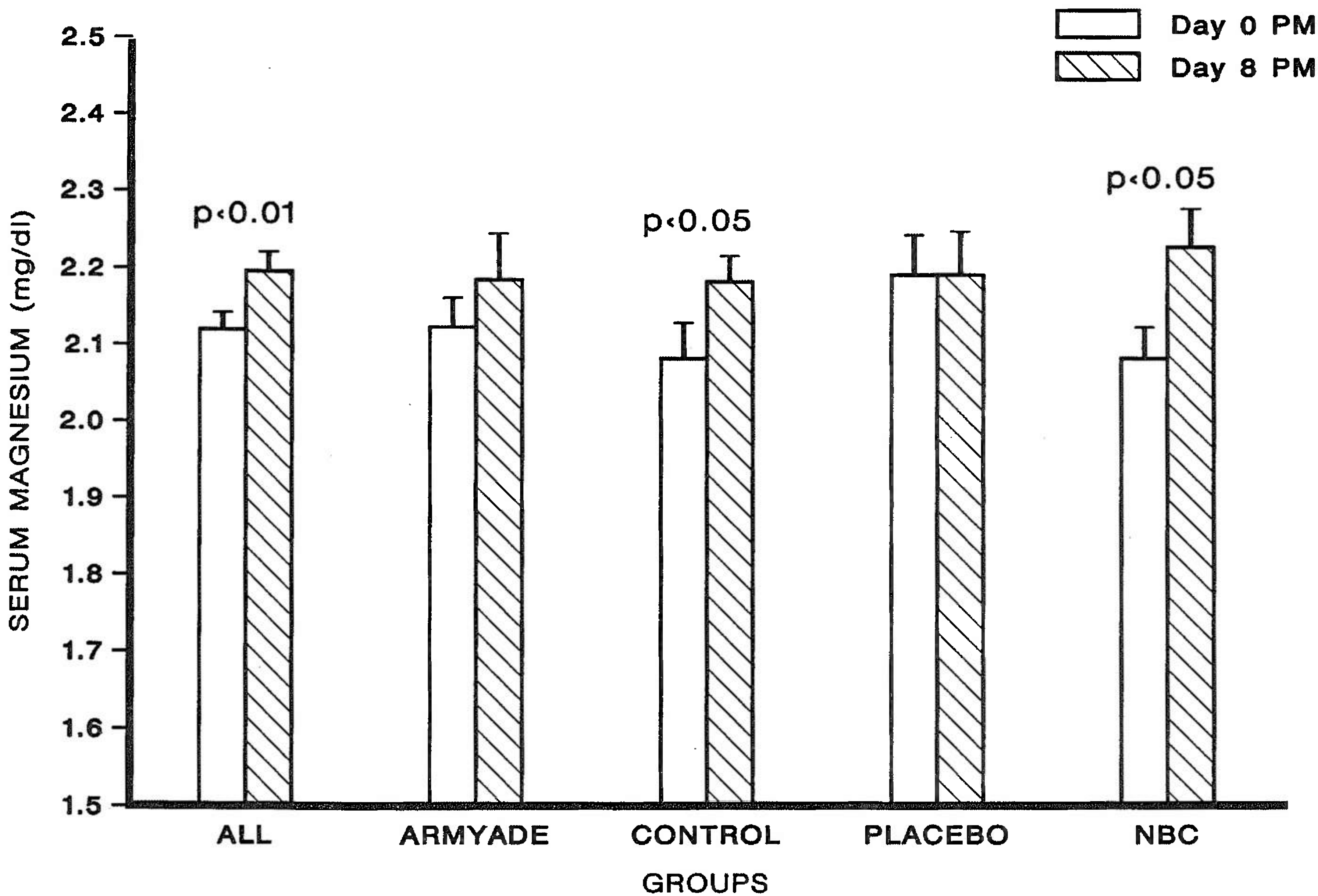


Figure 23. Serum magnesium (mean $\pm$ SE) before and after 8 days of work in the heat.

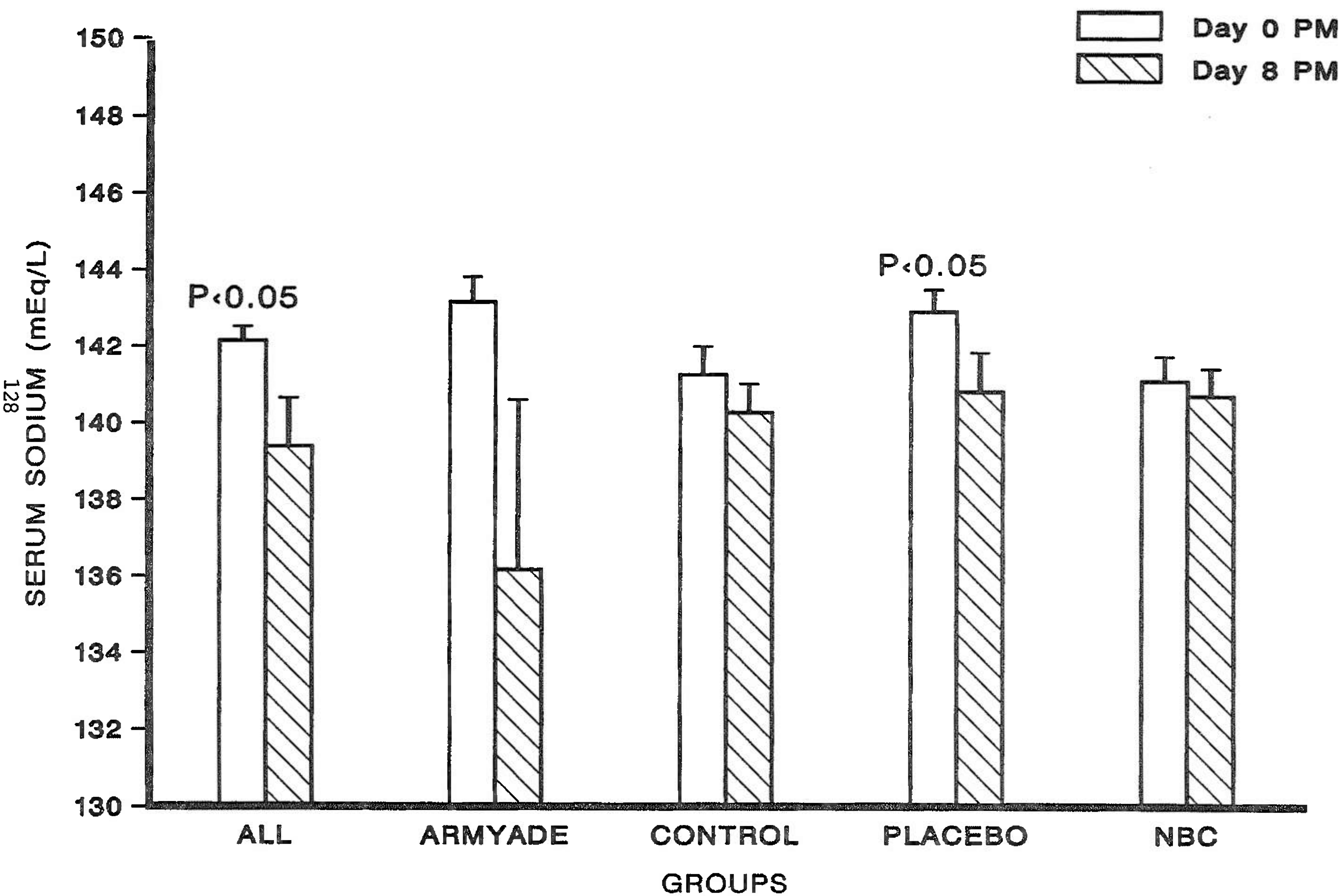


Figure 24. Serum sodium (mean ± SE) before and after 8 days of work in the heat.

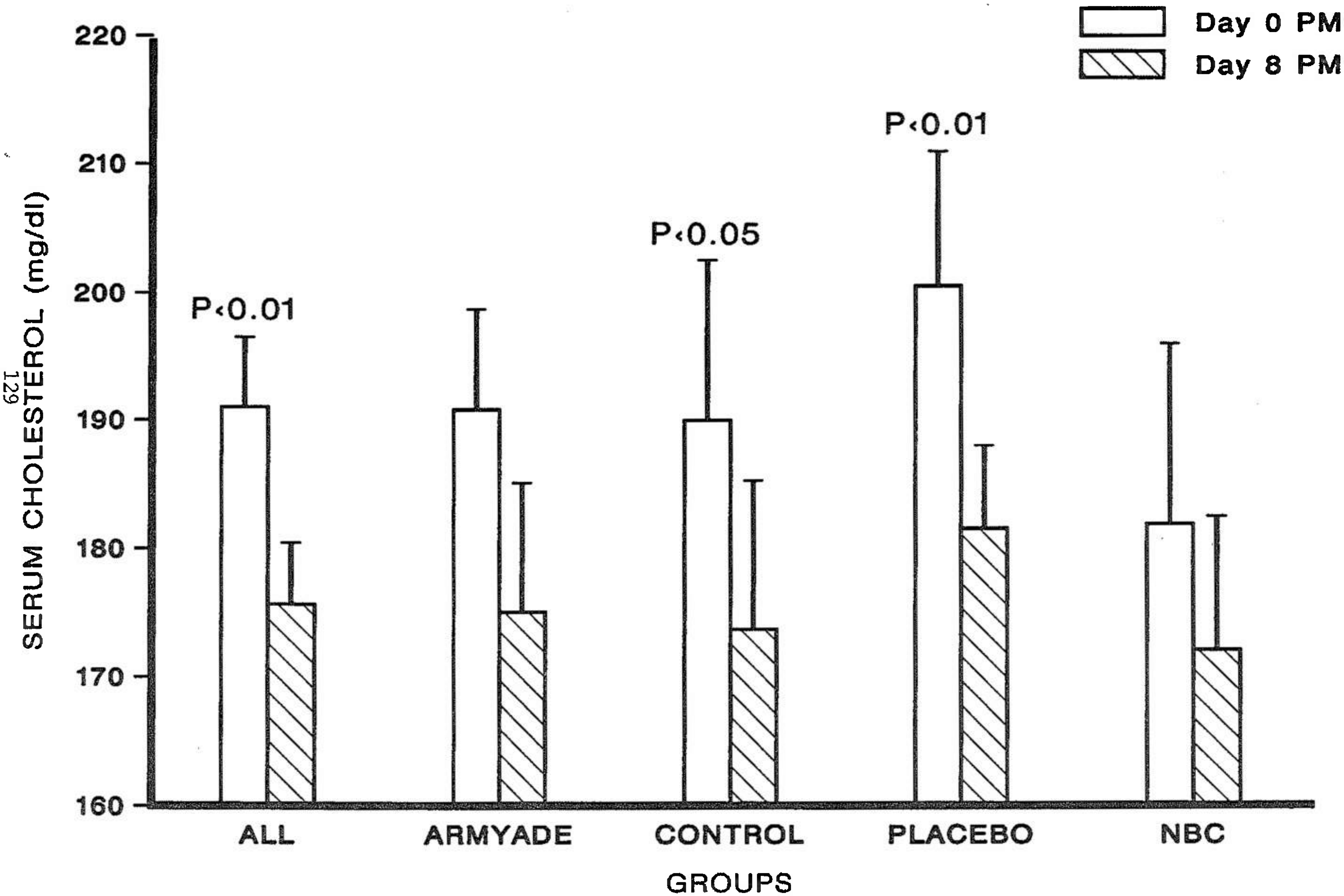


Figure 25. Serum cholesterol (mean ± SE) before and after 8 days of work in the heat.

BIOCHEMICAL INDICES

Serum Na^{+} was significantly decreased for the pooled subjects (142 vs 139 mEq/L, $p<0.05$) and for the Placebo Group (143 vs 141 mEq/L, $p<0.05$). The Placebo group drank a large amount of test beverage that was not supplemented with sodium (Table 20); however, the total sodium intake for this group was not significantly different from the other groups (Figure 9). Glucose was increased in the pooled data (88 vs 96 mg/dl, $p<0.05$) which was probably due to the significant increases in the NBC Group (83 vs 100 mg/dl, $p<0.01$) (Figure 22). Both Armyade and the NBC solution contained carbohydrates but the increase in serum glucose for the Armyade group was not significant. The significant increase in serum glucose could be attributed to the consistently higher intake (NS) of the NBC solution compared to Armyade but the carbohydrate content of both diets (to include test beverages) were similar (Table 31) at 388 and 390 g/day, respectively. The cholesterol values were significantly decreased for all pooled subjects ($p<0.01$) as well as in the Control group (190 vs 174 mg/dl, $p<0.05$) and in the Placebo Group (201 vs 182 mg/dl, $p<0.05$) (Figure 25). Serum magnesium was significantly increased ($p<0.05$) in the Control and NBC groups as well as in the mean data for all pooled subjects ($p<0.01$). Neither the NBC solution nor water was supplemented with magnesium. Analysis of dietary Mg^{++} intake by groups (Table 31) indicated that food intake did not contribute to these significant increases in serum Mg^{++}. The total intake of Mg^{++} in the Armyade group was twice as much as in the other groups but no significant differences were noted in serum values from Day 0 PM to Day 8 PM. Urine Mg^{++} concentrations were not statistically significant between groups. Whether total urine, sweat, or fecal Mg^{++} losses were decreased in the Control and NBC Groups to account for the increases in serum Mg^{++} cannot be defined from these studies and therefore remain unresolved. However, the absolute

values of these changes in Mg^{++} are well within the limits of normal and are therefore of no clinical significance. Supporting this view is the observation that none of the subjects in the field drinking water or NBC solution voiced any complaints related to clinical hypermagnesemia.

For the Armyade and NBC Groups the Na^{+}, K^{+} (Figure 26), Cl^{-}, and carbohydrate content of these beverages did not adversely affect serum electrolyte composition, although there was a small but statistically significant increase ($p<0.01$) in serum glucose in the NBC Group (Figure 22). In the group drinking Armyade, the only test beverage containing Mg^{++}, there was no statistically significant difference in serum Mg^{++} (2.12 vs 2.18 mEq/L). It should be noted that the Mg^{++} content of Armyade did not cause any gastrointestinal symptoms. Thus, in this study consumption of carbohydrate-electrolyte beverages under conditions of moderate heat stress did not result in clinically significant perturbations in serum electrolyte composition. Urine Na^{+}, K^{+} and Mg^{++} excretion was highest in those groups drinking the carbohydrate-electrolyte beverages (Armyade and NBC solution). These data are depicted in Figures 15 and 16. Thus intact renal function assures maintenance of normal serum electrolyte balance.

The BUN, creatinine, and calculated BUN/creatinine ratios were determined for each of the four groups. Changes were small and did not differ significantly. These data support the view that none of the groups were subjected to significant dehydration and are consonant with the lack of change in body weight as commented upon earlier (Figure 18) (67,87).

Estimation of cholesterol consumption in garrison range from 744 ± 219 (SD) mg/day at Fort Lewis and 761 ± 296 (SD) mg/day at Fort Riley (83). The daily cholesterol intake of the subjects in the present study was much lower at

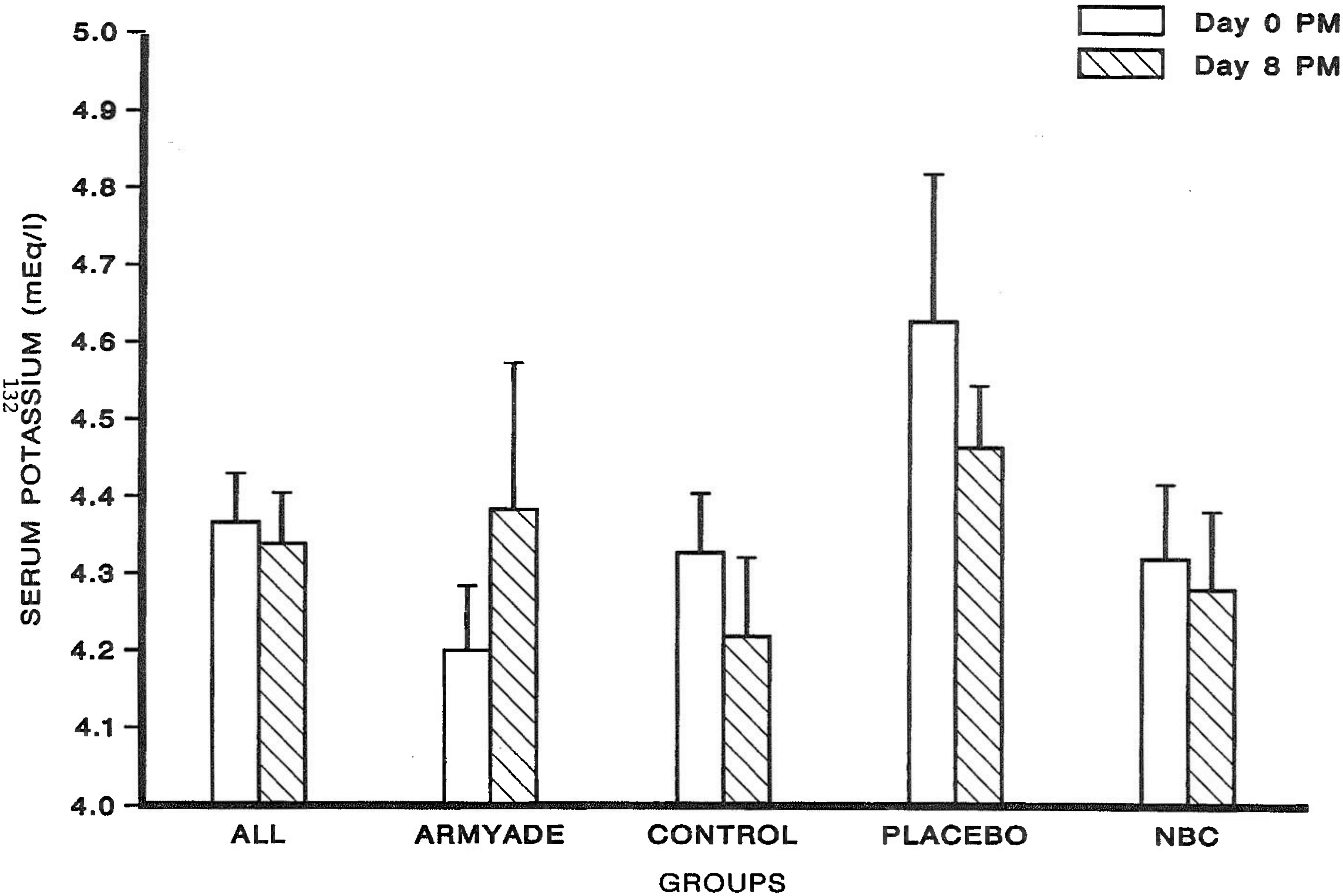


Figure 26. Serum potassium (mean ± SE) before and after 8 days of work in the heat.

523 ± 317 (SD) mg/day. Thus the significant decreases in serum cholesterol in the group as a whole, and in the Control, Placebo, and NBC Groups may reflect diminished dietary intake while consuming field rations. An additional factor contributing to the decrease in serum cholesterol could be increased physical activity in the field. While not achieving statistical significance, decreases in serum triglycerides (Figure 27) were noted for all groups except for the subjects consuming Armyade.

Serum phosphorus on Day 0 and Day 8 for all groups showed no changes resulting from drinking the different beverages. Armyade (3.2 mEq/L PO_4) and NBC solution (2.0 mEq/L PO_4) both contained phosphorus but there were no statistically significant differences in serum phosphorus resulting from drinking these beverages. Thus, drinking Armyade and NBC solutions under moderate heat conditions was disassociated from problems of hyperphosphatemia.

The data from the 4 study groups were subjected to an analysis of variance searching for statistically significant intergroup differences for Day 0 PM. At the start of the study the Placebo group showed statistically significant ($p<0.05$) differences for serum glucose, BUN, and chloride compared to the other groups. However, all these values are clinically within the normal ranges and the Day 8 PM values also appeared to be higher than in the other groups. Thus, the 4 study groups appeared to be homogeneous at the start of the study.

Although the majority of serum electrolyte changes were not statistically significant, the large decrement in serum sodium and small rise in serum potassium (Table 34) despite high urinary excretion (Figures 15,16,17) are worthy of comment. Although the total intake of sodium was similar for the Armyade and NBC groups, the Armyade group had higher urinary levels of sodium and potassium but lower

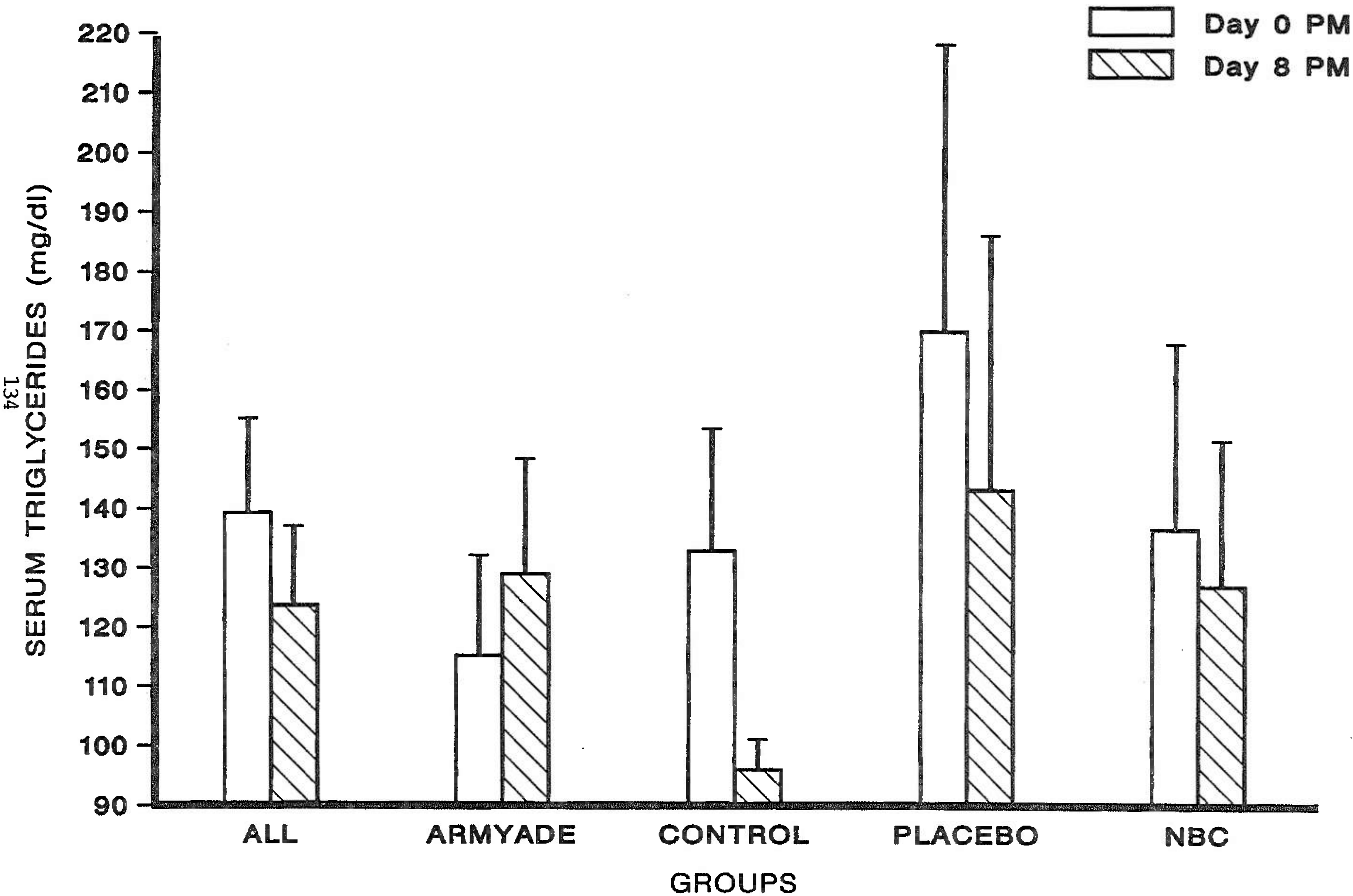


Figure 27. Serum triglycerides (mean ± SE) before and after 8 days of work in the heat.

serum sodium values. This unexpected fall in serum sodium accompanied by a small rise in serum potassium while drinking the Armyade beverage for 8 days is unexplained. We hypothesize that these unexpected changes may be the result of the ratio of sodium to potassium in Armyade (2.4:1) compared to the NBC solution (1250:1) and gatorade (9.1:1). In light of our results, the impact of the sodium to potassium ratio of Armyade solution on serum electrolytes should be addressed.

CONCLUSIONS

1. All serum electrolyte values were within normal range (but P_{Na^+} for Armyade is at the low end of normal). There were no clinically significant deviations in serum electrolyte composition (Na^+, K^+, Mg^{++}, Cl^-, PO_4) from drinking the carbohydrate-electrolyte beverages while under conditions of moderate heat stress.
2. Armyade and NBC solutions appear to be safe to consume under field conditions for up to 8 days as judged by minimal variances in serum electrolyte composition.
3. These studies did not maximally test the potential efficacy of Armyade or the NBC solution since the subjects were studied under conditions of moderate heat stress, light-moderate activity, and food availability.
4. Consumption of supplemental electrolytes in the carbohydrate-electrolyte beverages (Armyade and NBC solutions) resulted in increased renal excretion of electrolytes. Thus under moderate heat stress, consumption of field rations appears to be adequate to maintain electrolyte homeostasis.

RECOMMENDATIONS

The efficacy of Armyade and/or NBC solution in the prevention and treatment of heat injuries under conditions of maximum heat stress remains undefined by this study. Therefore another study should be carried out in troops undergoing combat arms training under maximum heat stress conditions to rigorously test the efficacy of these carbohydrate-electrolyte oral rehydration solutions.

CIRCULATORY SYSTEM FUNCTION

METHODS

A tilt-test was used to measure orthostatic hypotension tolerance in a random sample of subjects before (Day 1) and after (Day 8) consumption of assigned beverages. This test required about 4-8 minutes per subject and measured the blood pressure and heart rate responses to a change in position from supine to erect. Because the data were collected on selected individuals in the subject's work place, a tilt-table was not used to passively change the subject's position. Instead, subjects reclined for 4 minutes on a cot. With the aid of an investigator, the subject raised himself from the lying position to an erect (90^{o}) position, and remained standing for an additional 2 minutes. While other investigators have had subjects standing for 2 min up to 45 min, hemodynamic changes responsible for preventing a hypotensive response usually occur within the first 1-2 min (88,89). In the current protocol, subjects stood for only 2 min which allowed for collection of valuable data with minimal interference with their duties. Subjects displaying any symptoms of syncope during this maneuver were referred to the Medical Officer in Charge.

RESULTS AND DISCUSSION

Orthostatic hypotension can occur in normal healthy people subjected to strenuous exhaustive physical work or hot climates or both (90,91). Symptoms of hypotension represent the inability of the circulatory system to cope with precipitating factors such as dehydration and heat prostration.

A tilt-test was used to assess the integrity of adaptive circulatory mechanisms when changing position from horizontal to erect. Heart rate and blood pressure responses to the tilt-test were examined in 46 Reservists randomly selected from the four beverage groups.

Tables 35 and 36 show the group averages for blood pressure and heart rate changes when subjects raised themselves from the lying to standing position. For all groups, data on Days 1 and 8 show the expected increases in diastolic pressure and heart rate, and falls in the systolic and pulse pressures. We anticipated that differences in hypohydration between groups might be manifested by differences in the magnitude of the circulatory responses. For example, dehydration of 2.5-5% of initial body weight augments the rises in diastolic pressure and heart rate and the fall in pulse pressure (88,90,92). On either Day 1 or Day 8, there were no significant differences between groups in hydration status as measured by urine specific gravity and percent change in weight from pre-deployment. Not surprisingly, group averages were not different for any of the hemodynamic measures, and syncopal episodes and related symptoms did not occur in any of the individuals. A significant difference between hydration status and the circulatory response to the tilt-test might have been noted had we performed this maneuver during the evening hours of Day 4 ($WBGT_{max}$ = 90.3°F).

Table 35. Cardiovascular responses observed during tilt-test.

GROUP	TIME	USG	%ΔBW	SUPINE Psys	SUPINE Pdias	SUPINE HR	STANDING Psys	STANDING Pdias	STANDING HR	SUPINE PP	SUPINE BP	STANDING PP	STANDING BP
ARMYADE (N=7)	DAY 1	1.024 ±0.003	-0.90 ±0.52	124 ±6	68 ±4	74 ±1	123 ±4	77 ±3	86 ±4	61 ±3	89 ±4	46 ±3	93 ±3
	DAY 8	1.019 ±0.002	-0.65 ±0.30	124 ±5	74 ±3	71 ±3	121 ±3	80 ±4	80 ±5	54 ±4	92 ±4	42 ±3	94 ±3
CONTROL (N=10)	DAY 1	1.024 ±0.002	-0.83 ±0.33	126 ±5	72 ±4	77 ±4	119 ±4	81 ±3	82 ±4	53 ±3	90 ±4	38 ±3	94 ±3
	DAY 8	1.018* ±0.002	-0.99 ±0.49	120 ±4	69 ±3	70 ±4	115 ±4	77 ±3	73 ±4	51 ±3	86 ±3	38 ±3	90* ±3
PLACEBO (N=6)	DAY 1	1.017 ±0.003	-0.71 ±0.80	113 ±4	68 ±4	75 ±4	108 ±3	72 ±3	85 ±6	45 ±5	83 ±3	36 ±3	84 ±3
	DAY 8	1.018 ±0.004	-0.70 ±1.02	117 ±3	73 ±3	77 ±3	118 ±2	79 ±3	85 ±3	45 ±5	88 ±2	39 ±3	92** ±2
NBC (N=13)	DAY 1	1.017 ±0.002	-0.10 ±0.39	119 ±2	67 ±2	74 ±2	115 ±3	74 ±2	89 ±2	52 ±3	85 ±2	41 ±2	88 ±2
	DAY 8	1.020 ±0.002	-0.47 ±0.40	122 ±2	69 ±2	66*** ±4	121* ±2	78 ±2	75 ±4	54 ±4	86 ±2	43 ±2	92* ±2
GRAND MEAN (N=36)	DAY 1	1.021 ±0.001	-.055 ±0.24	121 ±2	69 ±2	75 ±2	116 ±2	76 ±1	84 ±2	52 ±2	86 ±1	40 ±2	90 ±1
	DAY 8	1.019 ±0.001	-0.68 ±0.26	121 ±2	70 ±2	70 ±2	119 ±2	78 ±1	77 ±2	51 ±2	87 ±2	41 ±1	92 ±1

Values are mean ± 1SEM.
Significance between Day 1 and Day 8: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Abbreviations:

USG	Urine specific gravity	Psys	Systolic pressure (mmHg)
%Δ BW	Percent change in body weight from predeployment	Pdias	Diastolic pressure (mmHg)
		PP	Pulse pressure (mmHg)
HR	Heart rate (BPM)	BP	Mean blood pressure (mmHg)

Table 36. Cardiovascular changes observed when going from supine to standing position.

GROUP	TIME	Δ HR@	Δ PP	Δ Psys	Δ Pdias	ΔBP
ARMYADE (N=7)	DAY 1	11 ±3	-13 ±5	-1 ±3	10 ±3	6 ±3
	DAY 8	9 ±3	-12 ±2	-3 ±3	8 ±2	4 ±2
WATER (N=10)	DAY 1	6 ±3	-15 ±3	-7 ±2	9 ±3	3 ±3
	DAY 8	5 ±2	-13 ±5	-5 ±3	8 ±3	3 ±2
PLACEBO (N=6)	DAY 1	11 ±9	-9 ±5	-5 ±3	4 ±4	1 ±3
	DAY 8	9 ±3	-6 ±3	0 ±3	6 ±1	4 ±1
NBC (N=13)	DAY 1	10 ±3	-11 ±2	-4 ±2	6 ±2	3 ±2
	DAY 8	9 ±2	-10 ±4	-1 ±1	9 ±3	6 ±2
GRAND MEAN (N=36)	DAY 1	10 ±2	-12 ±2	-4 ±1	7 ±2	3 ±1
	DAY 8	8 ±1	-11 ±2	-2 ±1	8 ±1	5 ±1

@Δ=STANDING-SUPINE; + = INCREASE; - = DECREASE
Values are mean ± 1SEM
No significant differences between Day 1 and Day 8 were observed.

CIRCULATORY SYSTEM FUNCTION

Significant differences between Day 1 and Day 8 were noted for several of the circulatory measures (Table 35). Of particular interest, on Day 8 both supine and standing heart rate were lower in the group consuming NBC solution and in the pooled data, and standing systolic pressure was higher in the groups drinking placebo and NBC solution. A lower heart rate was noted on Day 8 compared to Day 1 in all four groups (Table 35) but this was statistically significant only for the pooled data. Although a low heart rate during the tilt suggests an improved tolerance (93), it has also been correlated to a low resting heart rate (93,94). A significantly lower supine heart rate was observed for the pooled data on Day 8. The differences in hemodynamic responses probably did not result from a change in the orthostatic response of these individuals. Because these changes were not consistent between the groups, and the changes initiated when assuming an erect position from the supine position (Table 36) were not different between the two days, a more likely explanation for the apparent improvement is that many of the individuals underwent physical training and heat acclimation as a result of the intense physical labor during four days of severe heat stress (Days 1-4).

A remarkable variability was observed in hypohydration and/or impending hypohydration as measured by urine specific gravity and daily weight changes (see Hydration Status Section). Using these indices of impending hypohydration, the incidence of urine specific gravity $\geq$1.030 and/or % weight loss $\geq$3% of pre-deployment weight was calculated in the tilt-test population (Table 37).

Table 37. Number of samples displaying positive indices of impending hypohydration.

INDICES	DAY 1	DAY 8
USG[+] $\geq$ 1.030	6	1
%BWL[++] $\geq$ 3%	1	2
USG$\geq$1.030 + %BWL$\geq$3%	0	2
TOTAL # OF SAMPLES	7	5

USG[+] = urine specific gravity
%BWL[++] = % body weight loss from pre-deployment weight

The circulatory responses to the tilt-test for the twelve samples meeting these criteria are shown in Table 38. Because the criteria used to identify a positive tilt or hypotensive response to the tilt-test vary among reports (88,89,92,93), we selected, with the consult of an Emergency Medicine physician, the following as the rule of thumb:

Positive response to tilt
Fall in pulse pressure (PP) = 15 mmHg or
Increase in diastolic pressure (Pdias) = 10 mmHg or
Increase in heart rate (HR) = 20 bpm

We identified at least one positive circulatory change based on these guidelines in nine of these twelve samples.

Although weight loss is a good index of hypohydration in short-term studies in a controlled laboratory setting, we might expect the weight loss values of Day 8 to be more indicative of food intake than fluid consumption. Therefore, it is not surprising

Table 38. Circulating responses to tilt-test in subjects meeting criteria for impending hypohydration.

				SUPINE				STANDING								
TIME	SUBJECT	USG	% BW	Psys	Pdias	HR	PP	Psys	Pdias	HR	PP	Δ Psys@	ΔPdias	ΔHR	ΔPP	RESPONSE
USG > 1.030																
DAY 1	1	1.031	-0.7	138	66	82	72	136	86	88	50	-2	20	6	-22	+
	2	1.032	-1.7	144	78	76	66	128	92	96	36	-16	14	20	-30	+
	3	1.030	-1.1	120	72	72	48	116	74	88	42	-4	2	16	-6	-
	4	1.033	-2.5	118	80	84	38	120	90	76	30	2	10	-8	-8	+
	5	1.030	-2.6	128	62	80	66	136	84	88	52	8	22	8	-14	+
	6	1.030	0.0	108	72	84	36	94	66	96	28	-14	-6	12	-8	-
DAY 8	7	1.032	1.4	120	64	68	56	116	76	80	40	-4	12	12	-16	+
% BW > 3%																
DAY 1	8	1.009	-3.2	104	70	64	34	100	62	96	38	-4	-8	32	4	+
DAY 8	4	1.020	-3.0	132	80	64	52	132	80	56	52	0	0	-8	0	-
	9	1.028	-3.1	130	58	53	72	124	76	60	48	-6	18	7	-24	+
USG > 1.030 AND % BW > 3%																
DAY 8	10	1.030	-3.2	128	54	72	74	126	64	92	62	-2	10	20	-12	+
	8	1.032	-4.3	118	74	76	44	112	74	96	38	-6	0	20	-6	+

@Δ = STANDING - SUPINE.

that subject #4 displayed no response indicative of a positive tilt on Day 8.

Using urine specific gravity on Days 1 and 8 and percent body weight loss on Day 1 as indices of impending hypohydration, we observed nine positive tilt responses out of the eleven anticipated hypotensive responses (subject #4 Day 8 excluded).

Of notable interest are the positive results obtained from subjects #7 and #10. Subject #7 is a 40 year old male officer who was usually busy during both day and evening, and although he claimed that his fluid intake was adequate, he did not rehydrate well. His urine specific gravity averaged 1.029 for the first morning void and 1.031 for the afternoon sample. That his food consumption was adequate is shown by the gain in body weight. Subject #10 lost more than 3% of his pre-deployment body weight, and the specific gravity of his urine averaged 1.032 and 1.033 for the AM and PM samples, respectively. A positive response in several circulating variables in this subject was not at all surprising because he worked intensely setting up tents and keeping guard, and also displayed many symptoms of dehydration (e.g. irritability, apathy, lethargy, weariness, anorexia, and flushed skin) during the first five days of the field exercise.

The average values for the hemodynamic responses to the tilt-test grouped according to urine specific gravity $\geq$1.030 or body weight loss $\geq$3% are shown in Table 39. Individuals having urine specific gravity $\geq$1.030 had higher supine and standing heart rates compared to the 73 responders whose urine specific gravity <1.030. Mean values for diastolic (Pdias) and pulse (PP) pressures were different when individuals were grouped according to weight loss. These differences might reflect a greater hypotensive effect possibly resulting from hypohydration in individuals having urine specific gravity $\geq$1.030 and/or body weight loss $\geq$3%.

Table 39. Average values for tilt-test as defined by indices of impending hypohydration.

GROUP	N	SUPINE Psys	SUPINE Pdias	SUPINE HR	SUPINE PP	STANDING Psys	STANDING Pdias	STANDING HR	STANDING PP	ΔPsys@	ΔPdias	ΔHR	ΔPP
USG <1.030	73	120±1	69±1	71±1	52±1	118±1	77±1	79±1	41±1	-3±1	8±1	8±1	-11±1
USG ≥1.030	9	125±4	69±3	77±7+	56±5	120±4	78±3	89±2	42±4	-4±2	9±3	12±3	-14±3
BWL <3%	76	121±1	69±1	72±1	52±1	118±1	77±1	80±1	40±1	-3±1	9±1	9±1	-12±1
BWL ≥3%	5	122±5	67±5	66±4	55±8	119±6	71±3	80±9	48±4*	-4±1	4±5	14±6	-8±5

Values are mean ± 1SEM
+ Indicates statistical significance $p<0.10$
* Indicates statistical significance $p<0.07$
** Indicates statistical significance $p<0.02$
@Δ = STANDING-SUPINE

Based on these results, we conclude that measuring blood pressure and heart rate during a 4-8 minute tilt-test during which an individual assumes an upright position from a supine position, can be used in conjunction with the urine specific gravity to assess hypohydration or impending hypohydration in a field setting. The absence of highly significant differences between groups obscures the potential importance of the tilt-test as a diagnostic tool for impending hypohydration.

INTEGRATED SUMMARY

This report encompasses research activity related to four general areas: 1) acceptability and evaluation of oral carbohydrate-electrolyte solutions (NBC and Armyade), 2) correlation of on-site Wet Bulb Globe Temperature (WBGT) measurements with satellite-derived WBGT, 3) hydration status, and 4) circulatory system function.

Daily hedonic ratings of acceptability in the field and laboratory taste tests placed the NBC solution and the Placebo in the same range as water in terms of acceptability with the Armyade solution being significantly lower. Two subjects absolutely refused to drink their assigned test beverages (Armyade and Placebo) after the first day, but they did rate the acceptability of these beverages at the end of the study. Their data on acceptability of the test beverages and demographics were assigned to the appropriate groups, however, the biochemical, hydrational, food, and fluid consumption data were analyzed as if these two subjects belonged to the Control group.

The NBC group had a significantly higher ($p<0.001$) total fluid intake ($\bar{x}=5241\pm195$ ml/day) than the Armyade group ($\bar{x}=4097\pm185$ ml/day) when analyzed in terms of man-days. Mean daily fluid consumption for the entire study was 4672 ± 104 ml/day. The multivariate analysis of variance showed no significant differences between groups because of the small cell sizes, but there were significant differences over time and especially in relation to Day 4 (the hottest day of the study). Under the conditions of this study (light-moderate activity and moderate heat stress), there is no evidence that consuming carbohydrate-electrolyte solutions will enhance total fluid consumption over plain water. However, for the subjects in the Armyade, NBC, and Placebo groups, significant differences ($p<0.001$) were noted between the types of beverage drunk. The beverages for these groups were partitioned into Water, Colored

Flavored Test Beverage (CFTB), and Other. The Control group was not included in the CFTB analysis because plain water was the test beverage. Significantly greater ($p<0.001$) amounts of CFTBs were consumed when compared to plain water and Other beverages. The subjects drank 4x, 2.5x, and 10x as much CFTB as Water for the Armyade, NBC, and Placebo groups, respectively. The Armyade, Placebo, and NBC groups drank 11.8, 5.6, and 18.9%, respectively, of their total fluid as water. The soldiers in the Control group drank 65% of their total fluid as water. They would drink plain water when their only other choice was Other fluids probably because their access to ad libitum Other fluids may have been limited by the field situation.

None of the test beverages interfered with food intake judging by the isocaloric intake of all groups. Mean energy intake was lower than found in other studies at 2680±48 ml/day because of the inclusion of females with a lower mean intake of 2343±55 kcal/day. The mean energy intake of 3056±74 kcal/day for males only was very similar to of previous studies. The levels of energy intake for males and females came very close to meeting their energy needs. The subjects were able to maintain their body weight in the field with less than a 1 kg weight loss.

Biochemical analyses (12 serum clinical chemistries) revealed some statistically significant deviations in serum composition resulting from ingestion of the carbohydrate-electrolyte solutions but they were not physiologically significant. There were no observed adverse clinical effects resulting from drinking the carbohydrate-electrolyte beverages. However, drinking Armyade may cause potential problems because of the Na^{+}/K^{+} ratio. Urine electrolyte analyses demonstrated increased urinary electrolyte excretion in the NBC and Armyade groups suggesting that the body was excreting excess electrolytes. Further studies need to be conducted to determine if the problems are of significant physiological concern.

Statistical analyses showed that there were no significant differences between the 4 groups for total quantity of fluid ingested, total energy intake, energy intake from fluid and food (no test beverage), energy intake from food alone, and total potassium intake. The data showed significant differences over time for all of the comparisons. No significant interactions occurred between the groups over time so trends were essentially parallel between groups.

There were significant differences between the groups for energy intake from fluids ($p<0.05$), total sodium ingested ($p<0.05$), and the ratio of test beverage to total quantity of fluid drunk ($p<0.001$). The subjects drank significantly more ($p<0.05$) NBC solution than Other fluids and almost twice as much Water (NS). This indicates that palatable colored flavored fluid could improve fluid intake in the heat. At this activity level, under these heat stress conditions, and consuming regular meals, fluid intake is more important than electrolytes in maintaining hydration.

On-site WBGT readings at Fort Hood, TX correlated very well with the NOAA weather satellite readings. The results were very encouraging with the average difference between satellite-derived and surface WBGT measurements about $-1.8\pm3.8^{\circ}$F (Mean±SD).

Hydration status was monitored using twice daily weighings, urine specific gravity, urine electrolyte excretion, and the BUN/Creatinine ratio. These indices revealed that all 4 groups were, in general, eating and drinking adequately. On the hottest days of the study (Days 3 and 4), the subjects were consuming larger quantities of fluid; however, the intake for the Armyade and Control group may not have been sufficient. There was a greater incidence of urine specific gravities $\geq$ 1.030 on these days for the Armyade and Control groups compared to the NBC and Placebo groups. This study also demonstrated that hypohydration can be lessened by flavoring field grade water.

Measuring blood pressure and heart rate during a tilt-test was found to be a useful technique in conjunction with urine specific gravity to assess hypohydration or impending hypohydration in a field setting.

GENERAL CONCLUSIONS

1. Under conditions of light-moderate activity, moderate heat stress, and when other colored, flavored beverages are available, there is no evidence that providing a carbohydrate-electrolyte solution will enhance total fluid consumption over plain water.

2. When food intake is adequate, activity is light-moderate, and heat stress is moderate, consumption of water or non-nutritive flavored beverages is adequate to maintain electrolyte homeostasis.

3. Subjects consumed signficantly more of the colored, flavored test beverages (carbohydrate-electrolyte beverages and placebo) than water or other fluids when given the freedom to select any beverage and allowed to drink ad libitum.

4. Under the conditions of this study, carbohydrate-electrolyte beverages are not necessary to provide electrolytes but may be helpful in improving fluid intake when compared to plain water.

5. Consumption of carbohydrate-electrolyte beverages did not significantly alter food consumption.

6. Body weight was maintained in the field with losses less than 1 kg for 8 days.

7. According to the clinical chemistries, the ingestion of carbohydrate-electrolyte solutions was not accompanied by deviation from normal values. Drinking NBC and Armyade solutions appeared to be safe under the conditions studied.

8. The close correlation between field and satellite-derived WBGT readings indicates significant potential for the use of satellite remote sensing technology to accurately assess WBGT in training/operational environments.

9. Studies on hypohydration utilizing field expedient methodology (i.e., urine specific gravity, body weight, tilt-test, blood pressure, and pulse) are important and assist in evaluating body fluid status.

10. Soldiers in the NBC group drank significantly more fluid per day than those in the Armyade group. The Placebo and Control groups tended to drink consistently more than those in the Armyade group but the difference was not signficant. The NBC and Placebo groups had the smallest number of specific gravities $\geq$1.030. Preference for the Placebo suggested that soldiers preferred the coloring and flavoring over plain drinking water in the field.

11. Percent of individuals with urine specific gravities $\geq$1.030 were significantly different ($p<0.05$) between groups with subjects in the Placebo and NBC groups being better hydrated.

12. On days 1,3,4 for which there were significant differences ($p<0.05$) between groups, the water group was more hypohydrated than the groups drinking colored flavored solutions.

13. In a population of reservists consuming field rations during field exercise training, fluid intake can be enhanced and consequently, the incidence of hypohydration can be lessened, by coloring and flavoring the field drinking water with a non-nutritive or NBC nutrient solution.

14. Based on daily ratings, Armyade had a significantly lower hedonic rating than water (rated by Control group), placebo, or NBC Nutrient solution. The NBC Nutrient solution had a significantly higher rating than water but the difference was within one rating point.

15. The NBC solution had a significantly higher hedonic rating than Armyade; subjects in the NBC group drank significantly more total fluid/day than those in the Armyade group; and the incidence of hypohydration was significantly lower in the NBC group compared to the Armyade group. The placebo rating was intermediate.

16. The results from this study appear to confirm that urine specific gravity $\geq$ 1.030 and body weight loss $\geq$ 3% are reliable indices of hypohydration or impending hypohydration.

GENERAL RECOMMENDATIONS

1. Conduct further studies under rigorous heat stress where food intake is sporadic to assess the clinical efficacy of oral carbohydrate-electrolyte solutions (NBC, Armyade) since this investigation shows that the solutions can be used safely.
2. Continue refinement of the capability of satellite-derived WBGT.
3. Develop field expedient monitors of body hydration status.
4. Test the effectiveness of ad libitum consumption of carbohydrate-electrolyte solutions in preventing hypohydration in soldiers in MOPP4.
5. Joint research activities between Army Reserve units and Army Medical Research Laboratories should be pursued as a method of upgrading annual training of the Reserve Component as well as providing support for Army Medical Research Laboratory studies.
6. Potential importance of the tilt test as a diagnostic tool for impending hypohydration needs further study.

REFERENCES

1. Williams MH. Nutritional aspects of human physical and athletic performance. Springfield, IL: Charles C. Thomas Publisher, 1976:44-75 and 169-207.

2. Strydom NB, Wyndham CH, van Graan CH, Holdsworth LD, Morrison JF. The influence of water restriction on the performance of men during a prolonged march. So Afr Medical J 1966;31:539-544.

3. Macaraeg PVJ Jr. Influence of carbohydrate electrolyte ingestion on running endurance. In: Fox EL, ed. Report of the Ross symposium on nutrient utilization during exercise. Columbus, OH: Ross Laboratories, 1983:91-96.

4. Pitts GC, Johnson RE, Consolazio FC. Work in the heat as affected by intake of water, salt and glucose. Am J Physiol 1944;142:253-259.

5. Ladell WSS. The effects of water and salt intake upon the performance of men working in hot and humid environments. J Physiol 1955;127:11-46.

6. Adolph EF, Brown AH, Goddard DR, Gosselin RE, Kelly JJ, Molnar GW, Rahn H, Rothstein A, Towbin EJ, Wills JH, Wold AV. In: Physiology of man in the desert. New York: Interscience Publishers, 1947.

7. Wyndham CH. Heat stroke and hyperthermia in marathon runners. In: Milvy P, ed. The marathon: Physiological, medical, epidemiological, and psychological studies. New York: New York Academy of Sciences, 1977: 128-138.

8. Keys A, Brozek J, Henschel A, Mickelsen O, Taylor HL. Human starvation. U. of Minn Press, 1951.

9. Consolazio CF, Johnson RE, Pecora LJ. Physiological measurements of metabolic function in man. New York: Blakiston Division, McGraw-Hill Book Co., 1963.

10. Saltin B. Aerobic and anaerobic work capacity after dehydration. J Appl Physiol 1964;19:1114-1118.

11. Kenney RA. The effect of the drinking pattern on water economy in hot, humid environments. Brit J Industr Med 1954;11:38-39.

12. Kerndt PR, Naughton JL, Driscoll CE, Loxterkamp DA. Fasting: The history, pathophysiology and complications. West J Med 1982;137:379-399.

13. Szlyk PC, Hubbard RW, Matthew WT, Armstrong LE, Kerstein MD. Mechanisms of voluntary dehydration among troops in the field. Mil Med 1987;152:405-407.

14. Costill DL, Kammer WF, Fisher A. Fluid ingestion during distance running. Arch Environ Health 1970;21:520-525.

15. Foster C, Costill DL, Fink WJ. Gastric-emptying characteristics of glucose and glucose polymer solutions. Res Q Exer Sport 1980;51:299-305.

REFERENCES

16. Seiple RS, Vivian VM, Fox EL, Bartels RL. Gastric-emptying characteristics of two glucose polymers-electrolyte solutions. In: Fox EL, ed. Report of the Ross symposium on nutrient utilization during exercise. Columbus, OH: Ross Laboratories, 1983:85-87.

17. Costill DL, Saltin B. Factors limiting gastric emptying during rest and exercise. J Appl Physiol 1974;37:679-683.

18. Hunt JN. The site of receptors slowing gastric emptying in response to starch in test meals. J Physiol 1960;154:270-276.

19. Coyle EF, Costill DL, Fink WJ, Hoopes DG. Gastric emptying rates for selected athletic drinks. Res Q 1978;49:119-124.

20. Daum F, Cohen MJ, McNamara H, Finberg L. Intestinal osmolality and carbohydrate absorption in rats treated with polymerized glucose. Pediatr Res 1978;12:24-26.

21. Elias E, Gibson GJ, Greenwood LF, Hunt JN, Tripp JH. The slowing of gastric emptying by monosaccharides and disaccharides in test meals. J Physiol 1968;194:317-326.

22. Hunt JN, Pathak JD. The osmotic effects of some simple molecules and ions on gastric emptying. J Physiol 1960;154:254-269.

23. Neufer PD, Costill DL, Fink WJ, Kirwan JP, Fielding RA, Flynn MG. Effects of exercise and carbohydrate composition on gastric emptying. Med Sci Sports Exerc 1986;18:658-662.

24. Pirnay F, Lacroix M, Mosora F, Luyckx A, Lefebvre P. Effect of glucose ingestion on energy substrate utilization during prolonged muscular exercise. Eur J Applied Physiol 1977;36:247-254.

25. Bonen A, Malcolm SA, Kilgour RD, MacIntyre KP, Belcastro AN. Glucose ingestion before and during intense exercise. J Appl Physiol 1981;50:766-771.

26. Brooke JD, Davis GJ, Green LF. The effects of normal and glucose syrup work diets on the performance of racing cyclists. J Sports Med 1975;15:257-265.

27. Ivy JL, Costill DL, Fink WJ, Lower RW. Influence of caffeine and carbohydrate feedings on endurance performance. Med Sci Sports 1979;11:6-11.

28. Ahlborg G, Felig P. Substrate utilization during prolonged exercise preceded by ingestion of glucose. Am J Physiol 1977;233:E188-E194.

29. Bueding E, Goldfarb W. Blood Changes following glucose, lactate and pyruvate injections in man. J Biol Chem 1943;147:33-40.

30. Hermansen L, Pruett EDR, Osnes JB, Giere FA. Blood glucose and plasma insulin in response to maximal exercise and glucose infusion. J Appl Physiol 1970;29:13-16.

31. Wahren J, Felig P, Ahlborg G, Jorfeldt L. Glucose metabolism during leg exercise in man. J. Clin Invest 1971;50:2715-2725.

32. Norris WA, Kanonchoff AD, Prall V, Rupp J, Fox EL, Bartels RL, Hecker AL. Metabolic response to an experimental hydration solution in long-term exercise. In: Fox EL, ed. Report of the Ross symposium on nutrient utilization during exercise. Columbus, OH: Ross Laboratories, 1983:87-91.

33. Hughes S. Acute secretory diarrhoeas: Current concepts in pathogenesis and treatment. Drugs 1983;26:80-90.

34. Costill DL. Sweating: Its composition and effects on body fluids. In: Milvy P, ed. The marathon: Physiological, medical epidemiological, and psychological studies. New York: New York Academy of Sciences, 1977: 160-174.

35. Kozlowski S, Saltin B. Effect of sweat loss on body fluids. J Appl Physiol 1964;19:1119-1124.

36. Frizzell RT, Lang GH, Lowance DC, Lathan SR. Hyponatremia and ultramarathon running. JAMA 1986;255:772-774.

37. Committee on Dietary Allowances, Food and Nutrition Board, Commission on Life Sciences, National Research Council. Recommended Dietary Allowances. 9th ed. Washington, DC: National Academy Press, 1980.

38. Maron MB, Wagner JA, Horvath SM. Thermoregulatory responses during competitive marathon running. J Appl Physiol 1977;42:909-914.

39. Kutsky RJ. Handbook of vitamins, minerals and hormones. 2nd ed. pp. 30-41.

40. Whang R, Welt LG. Observations in experimental magnesium depletion. J Clin Inves 1963;43:305.

41. Ryan MP, Whang R, Yamalis W. Effect of magnesium deficiency on cardiac and skeletal muscle potassium during dietary potassium restriction. Proc Soc Exp Biol Med 1973;143:1045.

42. Whang R, Morosi HJ, Rogers D, Reyes R. The influence of continuing magnesium deficiency on muscle K^+ repletion. J Lab Clin Med 1967;70:895.

43. Whang R, Aikawa JK. Magnesium deficiency and refractoriness to potassium repletion. J Chron Dis 1977;30:65.

44. Whang R, Flink EB, Dyckner T, Wester PO, Aikawa JK, Ryan MP. Magnesium depletion as a cause of refractory potassium repletion. Arch Int Med 1985;145:1686-1689.

45. Costill DL, Cote R, Fink WJ. Dietary potassium and heavy exercise: Effects on muscle water and electrolytes. Am J Clin Nutr 1982;36:266-275.

REFERENCES

46. Rose MS, Carlson DE. Effects of A-ration meals on body weight during sustained field operations. (Technical Report No. T2-87) Natick, MA: US Army Research Institute of Environmental Medicine, 1986.

47. Whang R. Magnesium deficiency: Causes and clinical implications. Drugs 1984;28 (supp 1):143-150.

48. Kaufman CE, Felsenfeld AJ, Vannatta JB, Whang R, Llach F. Maintenance of body fluid potassium, calcium, magnesium, and phosphorus. In: Frohlich ED, ed. Pathophysiology Third Edition. Philadelphia, PA: JB Lippincott, 1984:249-269.

49. Whang R. Medical and health aspects of potassium. In: Munson RD, ed. Potassium in agriculture. Madison, WI: American Society of Agronomy, 1985:621-633.

50. Papper S, Whang R. Hypokalemia and hyperkalemia. Disease-A-Month, June 1964.

51. Knochel JP. The pathophysiology and clinical characteristics of severe hypophosphatemia. Arch Int Med 1977;137:203.

52. Conclusions and recommendations arising from a workshop, held June 3-4, 1982, to determine nutritional requirements of military personnel in protective clothing. Committee on Nutritional Requirements in Protective Clothing, Food and Nutrition Board, Commission on Life Sciences, National Research Council.

53. Rose MS, Francesconi R, Levine L, Shukitt B, Cardello A, Warren P, Munro I, Banderet L, Poole P, Frykman P, Sawka M. Effects of a NBC nutrient solution on physiological and psychological status during sustained activity in the heat. USARIEM, Natick, MA. Technical Report No. T25-87, July 1987.

54. Palmer DL, Koster FT, Rafiqul Islam AFM, Mizanur Rahman ASM, Sach RB. Comparison of sucrose and glucose in the oral electrolyte therapy of cholera and other severe diarrheas. New Eng J Med 1977;297:1107-1110.

55. Guerrant RL, Shields DS, Thorson SM, Schorling JB, Groschel DHM. Evaluation and diagnosis of acute infectious diarrhea. Am J Med 1985;78:91-98.

56. Pawan GLS. Fructose. In: Birch GG, ed. Mol Struct Funct Food Carbohydrates. Industry-University Cooperative Symposium 1973. NY: Wiley, 1973:65-80.

57. Fruth JM, Gisolfi CV. Effects of carbohydrate consumption on endurance performance: Fructose versus glucose. In: Fox EL, ed. Report of the Ross symposium on nutrient utilization during exercise. Columbus, OH: Ross Laboratories, 1983:68-75.

58. Washington University Manual of Medical Therapies. 25th ed. Boston, MA:Little Brown & Co., 1986:43.

59. Lau K. Magnesium metabolism: Normal and abnormal. In: Ariess AI, DeFronzo RA, eds. Fluid, Electrolyte and Acid Base Disorders. NY: Churchill Livingston, 1985:575-623.

60. Ahlborg B, Bergstrom J, Ekelund LG, Hultman E. Muscle glycogen and muscle electrolytes during prolonged physical exercise. Acta Physiol Scand 1967;70:129-142.

61. Hubbard RW, Sandick BL, Matthew WT, Francesconi RP, Sampson JB, Durkot MJ, Maller O, Engell DB. Voluntary dehydration and alliesthesia for water. J Appl Physiol 1984;57:868-875.

62. Sohar E, Kaly J, Adar R. The prevention of voluntary dehydration. UNESCO/India Symposium on Environmental Physiology and Psychology, 1962:129-135.

63. Sandick BL, Engell DB, Maller O. Perception of drinking water temperature and effects for humans after exercise. Physiol Beh 1984;32:851-855.

64. US Army Combat Developments Experimentation Center, Fort Ord, CA and US Army Research Institute of Environmental Medicine, Natick, MA. Combat Field Feeding System-Force Development Test and Experimentation (CFFS-FDTE) Test Report CDEC-TR-85-006A, 1986.

65. Tietz N., ed. Fundamentals of clinical chemistry. Philadelphia, PA: W.B. Saunders Co., 1976.

66. Rothstein A, Adolph EF, Wills, JH. Voluntary dehydration. In: Adolph EF, ed. Physiology of man in the desert. New York: Interscience, 1947:254-270.

67. Francesconi RP, Hubbard RW, Szlyk PC, Schnakenberg D, Carlson D, Leva N, Sils I, Hubbard L, Pease V, Young J, Moore D. Urinary and hematologic indexes of hypohydration. J Appl Physiol 1987;62:1271-1276.

68. TB MED 507 (NAVMED P-5052-5, AFP 160-1) Occupational and Environmental Health: Prevention, and Control of Heat Injury. Headquarters, Departments of the Army, Navy, and Air Force, 1980.

69. DA Cir. 40-82-3, Prevention of Heat Injury. Headquarters, Department of the Army, (Interim Changes: Issued July 1982, Expired July 1984).

70. GTA 8-5-45 Heat Injury Prevention and First Aid. Headquarters, Department of the Army, August 1985.

71. Bandy JT, Smith ED, Hubbard R, Sandick B, Matthew WT, Thomas G, Testa M. Bright star 83 after action report: Water management (Production/Consumption) and heat stress management. US Army Construction Engineering Research Lab, USA Natick Research & Development Center, and USA Research Institute of Environmental Medicine. March 1984.

REFERENCES

72. Peryam DR, Girardot NF. Advanced taste-test method. Food Engineering 1952;58:194.

73. Popper R, Hirsch E, Lesher L, Engell D, Jezior B, Bell B. Field Evaluation of Improved MRE, MRE VII, and MRE IV. USANRDC Technical Report No. TR-87/027, 1987.

74. Beecher HK. Measurement of subjective responses: Quantitative effects of drugs. New York: Oxford U. Press, 1959.

75. Engell D, Edinberg J, Abrams I. Effect of beverage variety on beverage and food intake in humans. Paper presented at the Neuroscience Satellite Conference, November, 1987, San Antonio, TX.

76. Cardello, AV. Acceptance and human factors data collected on prototype NBC beverage and packaging during Exercise CANE. Internal Memo, May, 1983.

77. Cardello AV, Darsch GA. A feeding system for use with chemical protective suits: product development and user acceptance. Paper presented at the Annual Meeting of the Institute of Food Technologists, Las Vegas, June 1987.

78. Ellis BH. Acceptance and consumer preference testing. J. Dairy Sci., 1969, 52:833.

79. Rosenthal R. Experimenter effects in behavioral research. New York: Appleton, 1966.

80. Rose MS, Buchbinder JC, Dugan TB, Szeto EG, Allegretto JD, Rose RW, Carlson DE, Samonds KW, Schnakenberg DD. Determination of nutritional intakes by a modified visual estimation method and computerized nutrition analysis for dietary assessments of military field and garrison feeding. USARIEM Technical Report No. T6-88, 1987.

81. Army Regulation 40-25. Nutrition Allowances, Standards, and Education. Headquarters, Departments of the Army, the Navy, and the Air Force. Washington, DC, 15 May 1985.

82. Hirsch E, Meiselman HL, Popper RD, Smith G, Jesior B, Lichton I, Wenkam N, Burt J, Fox M, McNutt S, Thiele MN, Dirige O. The effects of prolonged feeding meal, ready-to-eat (MRE) operational rations. USANRDC Technical Report No. TR-85/035, 1983.

83. Szeto EG, Carlson DE, Dugan TB, Buchbinder JC. A comparison of nutrient intakes between a Ft. Riley contractor-operated and a Ft. Lewis military-operated garrison dining facility. USARIEM Technical Report No. T2-88, 1987.

84. Szeto EG, TB Dugan, Gallo JA. Assessment of habitual diners nutrient intakes in a military-operated garrison dining facility Fort Devens I. USARIEM Technical Report No. T3-89, 1988.

85. Rose RW, Baker CJ, Salter C, Wisnaskas W, Edwards JSA, Rose MS. Dietary assessment of U.S. Army basic trainees at Fort Jackson, SC. USARIEM Technical Report No. T6-89, 1989.

86. Szlyk, PC, Sils IV, Francesconi RP, Hubbard RW, Matthew WT. Variability in intake and dehydration in young men during a simulated desert walk. Aviat Space Environ Med (In Press).

87. Dossetor JB. Creatininemia versus uremia. Ann Int Med 1966;65:1287-1299.

88. Beetham WP, Buskirk ER. Effects of dehydration, physical conditioning and heat acclimation on the response to passive tilting. J Appl Physiol 1958; 13:465-468.

89. White NJ. Heart rate changes on standing in elderly patients with orthostatic hypotension. Clin Sci 1980; 58:411-413.

90. Eichna LW, Bean WB. Orthostatic hypotension in normal young men following physical exertion, environmental thermal loads, or both. J Clin Invest 1944; 23:942.

91. Horvath SM, Botelho SY. Orthostatic hypotension following hot or cold baths. J Appl Physiol 1949; 1:586-596.

92. Harrison MH, Hill LC, Spaul WA, Greenleaf JE. Effect of hydration on some orthostatic and haematological responses to head-up tilt. Eur J Appl Physiol 1986; 55:187-194.

93. Dikshit MB, Banerjee PK, Rao PLN. Orthostatic tolerance of normal Indians and those with suspected abnormal cardiovascular reflex status. Aviat Space Environ Med 1986; 57:168-173.

94. Shvartz E, Strydom NB, Kotze H. Orthostatism and heat acclimation. J Appl Physiol 1975; 39:590-595.

APPENDIX A - FORMULATION AND COMPOSITION OF NBC NUTRIENT SOLUTION, ARMYADE, AND PLACEBO

APPENDIX A-1

NBC NUTRIENT SOLUTION POWDER FORMULA

INGREDIENTS	g/l
Malti Dextrin-42	10.3960
Fructose	14.4372
Aspartame	0.1060
Salt 1.3250	
Citric acid	2.6500
Tricalcium phosphate	0.3890
Sodium benzoate	0.2120
LL Flavor Fries & Fries 88481	0.0636
LL Flavor Fries & Fries 88484	0.0424
LL Flavor Fries & Fries 80523	0.0530
FDC Yellow color #5	0.0016
Lime shade McCormick C00266	0.0042

APPENDIX A-2

ARMYADE FORMULA

INGREDIENTS	g/L
Malti Dextrin-42	25.0000
Aspartame	0.1060
Magnesium Chloride	0.406
$NaHCO_3$	0.8581
Potassium Chloride	0.6710
Citric acid	2.6500
Tricalcium phosphate	0.778
Sodium Chloride	0.5856
Sodium benzoate	0.212
LL Flavor Fries & Fries 88481	0.0636
LL Flavor Fries & Fries 88484	0.0424
LL Flavor Fries & Fries 80523	0.0530
FDC Yellow color #5	0.0016
Lime shade McCormick C00266	0.0042

APPENDIX A-3

PLACEBO SOLUTION

	g/l
LL Flavor Fries & Fries 88481	0.0636
LL Flavor Fries & Fries 88484	0.0424
LL Flavor Fries & Fries 80523	0.0530
FDC Yellow color #5	0.0016
Lime shade McCormick C00266	0.0042
Aspartame	0.1060

APPENDIX A-4

Comparison of the energy, carbohydrate and electrolyte content, and osmolality of Armyade, NBC Nutrient Solution, and Placebo.

FLUID	ELECTROLYTES (mEq/L)						Carbohydrate (g/L)	Energy (kcal/L)	Osmolality (mOsm/kg)
	Na^+	Cl^-	K^+	HCO_3	Mg^{++}	PO_4			
Armyade	22.8	25.5	9.5	10	5.2	3.2	25	100	127
NBC Nutrient Soln	25.0	24	0.02		0.14	2.0	24.8	99	166
Placebo	0	0	0	0	0	0	0	0	2

APPENDIX B - LIST OF DEPENDENT VARIABLES

APPENDIX

DEPENDENT VARIABLES:

Weight

after urine collection in morning and afternoon (2 min)

Urine

Weight (for 24-hour collection only)

Specific Gravity - first morning urination in container (2 min)

afternoon urination (2 min)

Dipstick

Analysis for Na^+, K^+, Mg^{++}, creatinine

Solution Acceptability

rating on fluid intake card (2 min)

post-test questionnaire (20 min)

Fluid Consumption 24 hour

mark canteen numbers at source of water

soldiers keep cards - 24-hr

Food Intake at Meals - Visual Estimation Method

Na^+-individual packets

No. of Meals-VEM

Caloric Intake-VEM

Fluid intake at meals

Food Intake between meals and MRE for lunch

soldiers mark snacks and MRE foods on fluid cards

Orthostatic Hypotension

4-8 min/individual

selected subjects from each group (ie ambulance drivers, aidmen, etc.) will be tested during free time during Day 1 and Day 8.

test also will be administered to subjects displaying symptoms of dehydration/heat injury

Evaluation of heat casualties (exhaustion and cramps)

Questionnaire

Body Weight

24 hour urine collection

rectal temperature

Total Body Water-stable isotope-2 16-ml draws

Clinical enzymes and electrolytes obtained from first blood draw

for heat exhaustion and cramps patients after seen by doctor and able to talk

not applicable to heat stroke or severe heat exhaustion patients who will be evacuated from the area

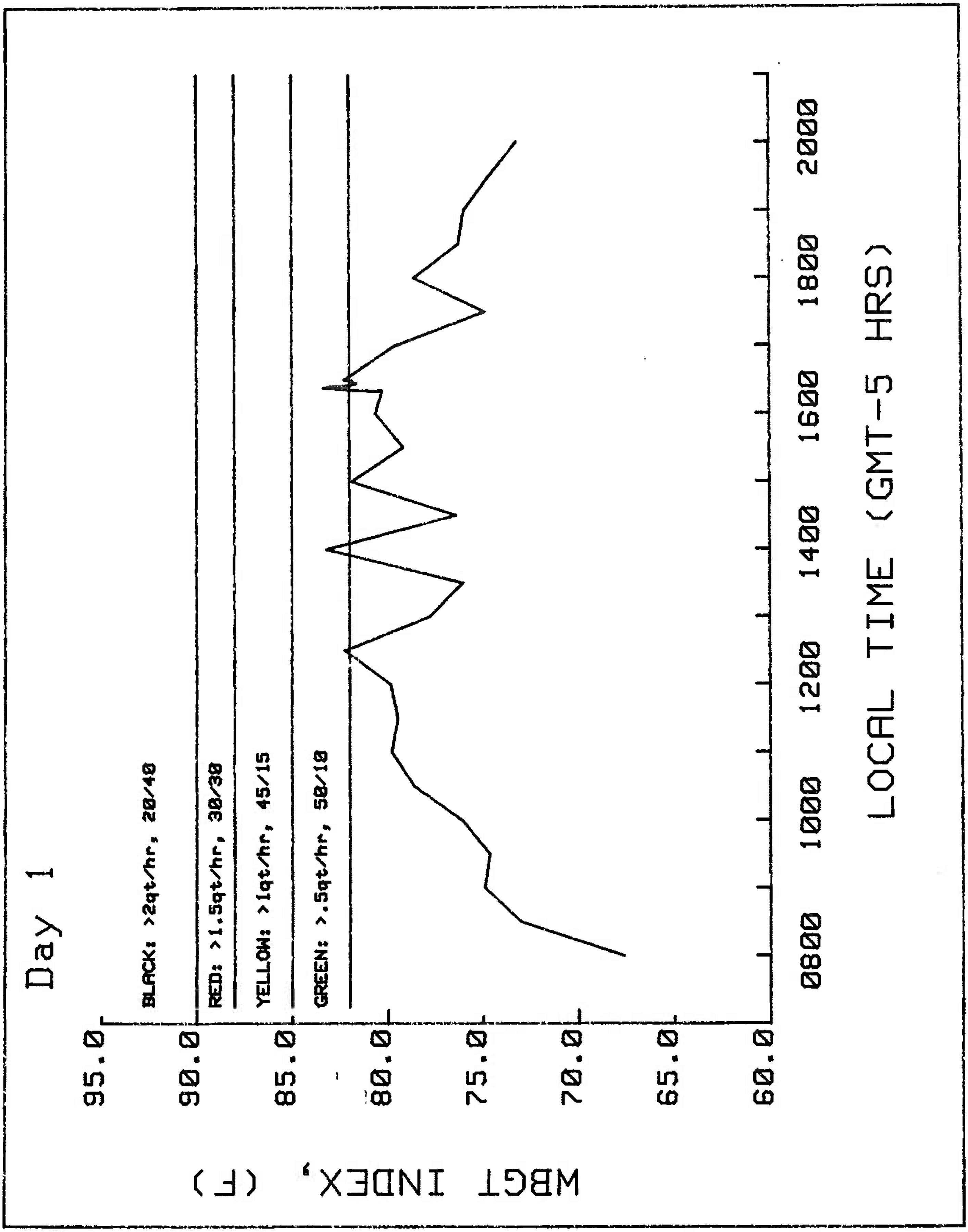
Wet Bulb Globe Temperature

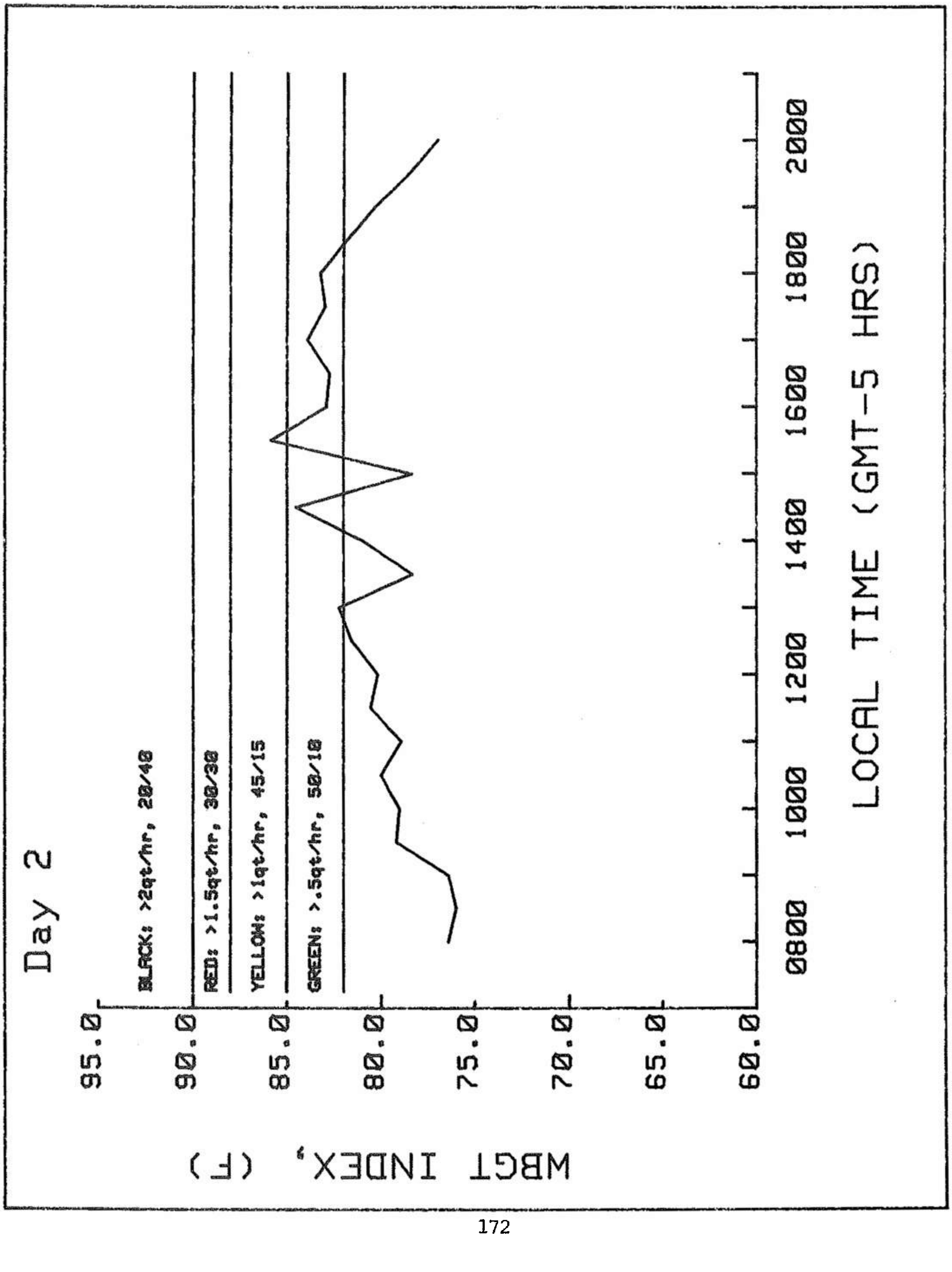
Satellite

Ground Readings

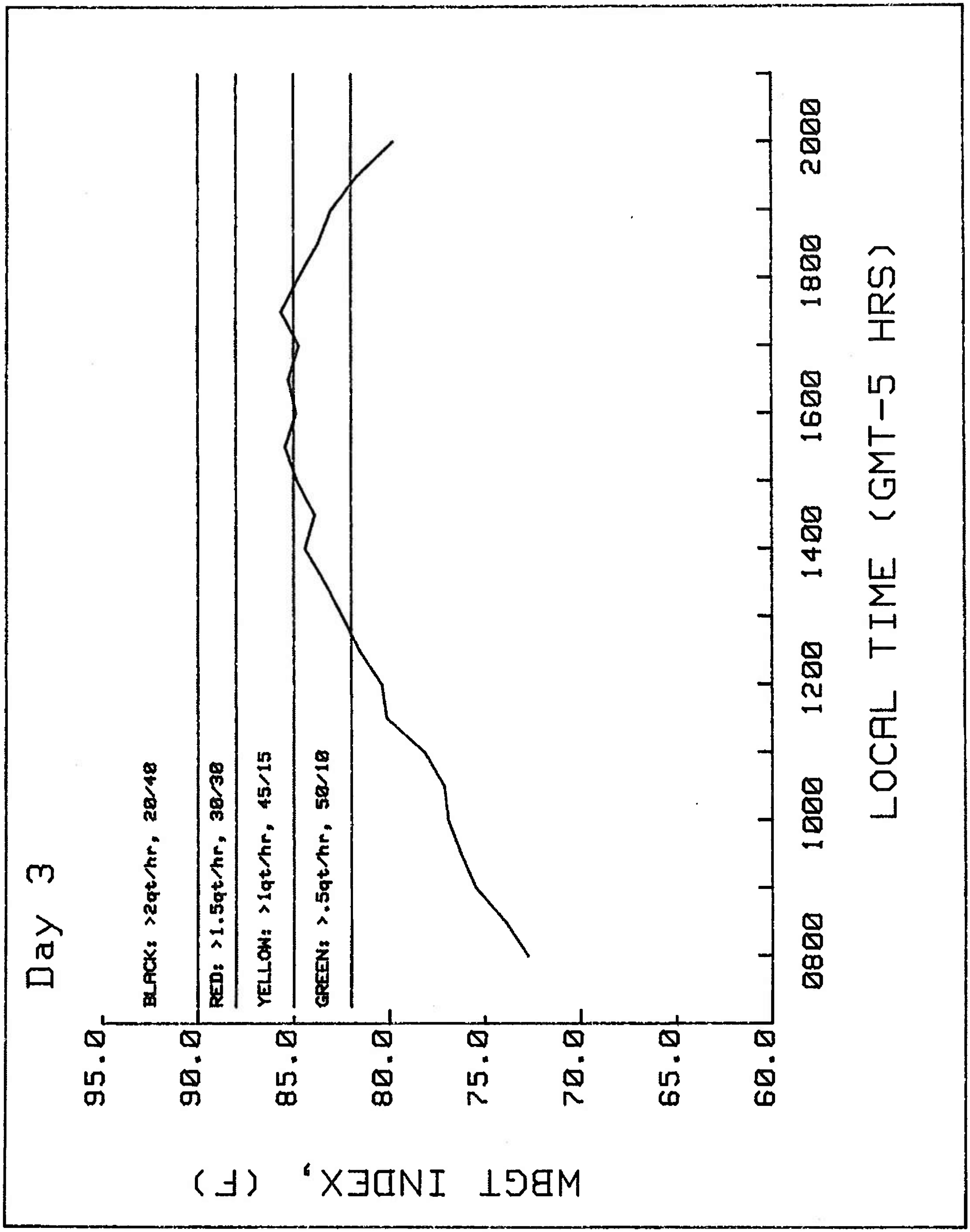
Unit readings

APPENDIX C - WBGT PROFILES OF FLUID RECOMMENDATIONS

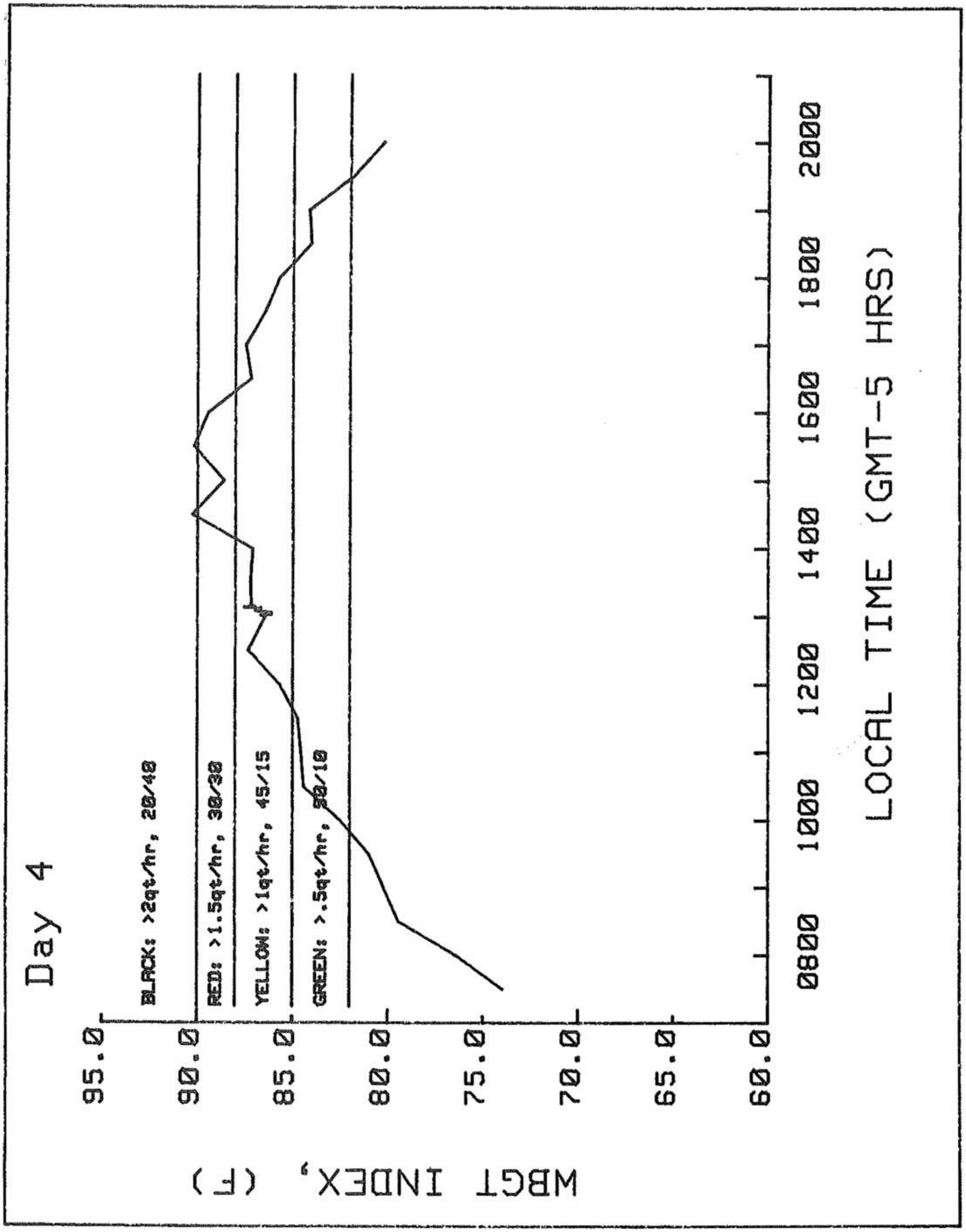

Day 1
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
WBGT INDEX, (F)
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)

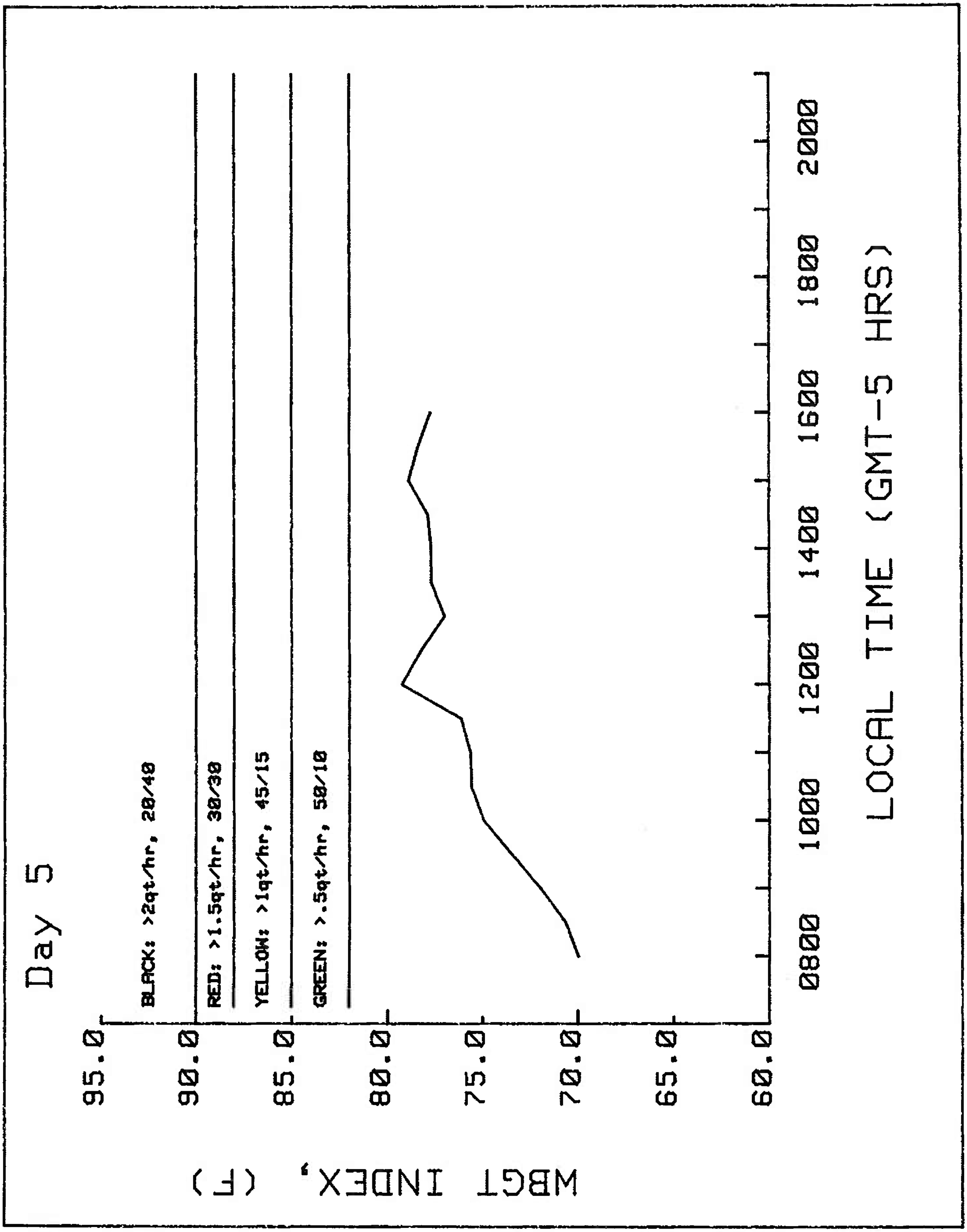


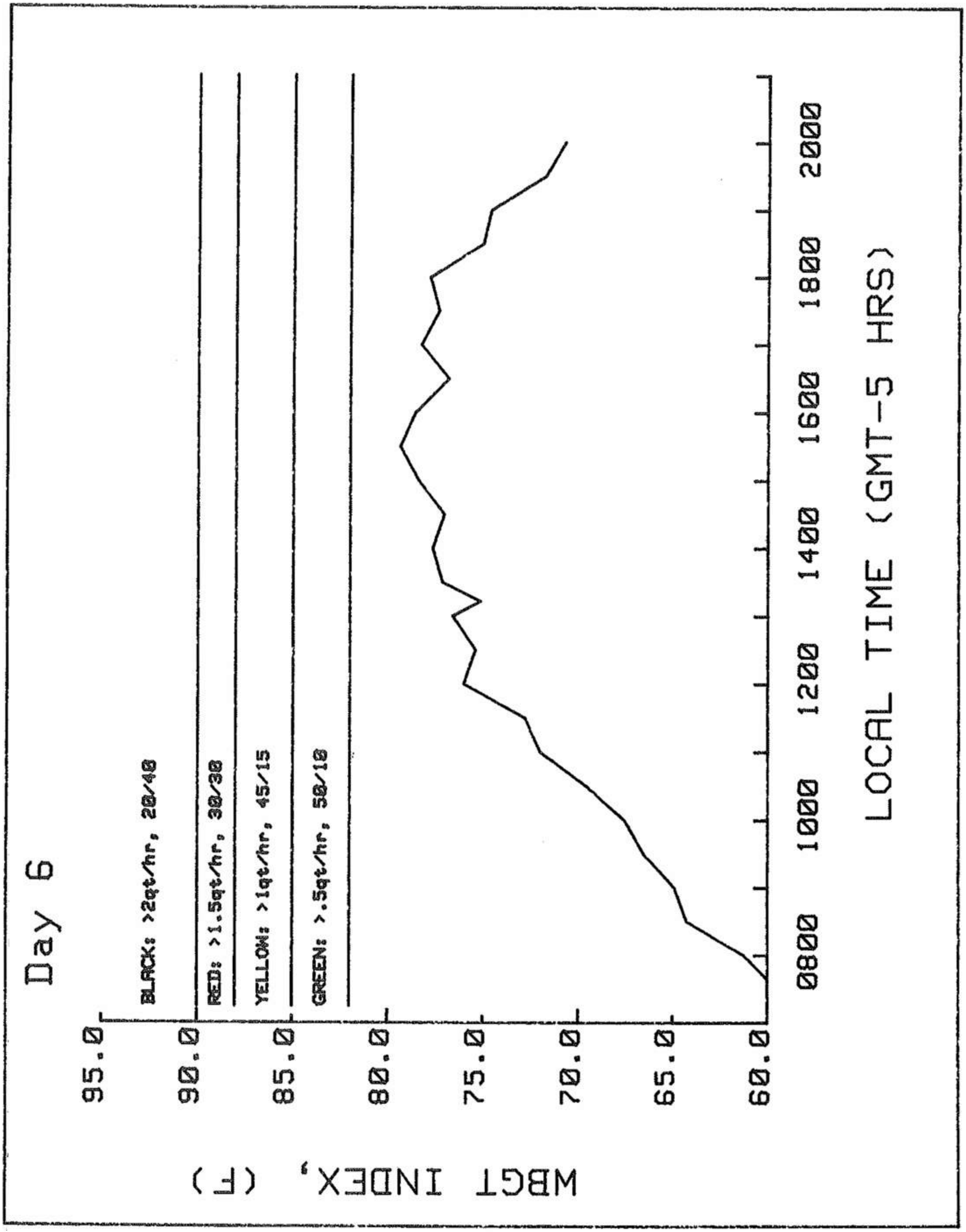
Day 2
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
WBGT INDEX, (F)
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)

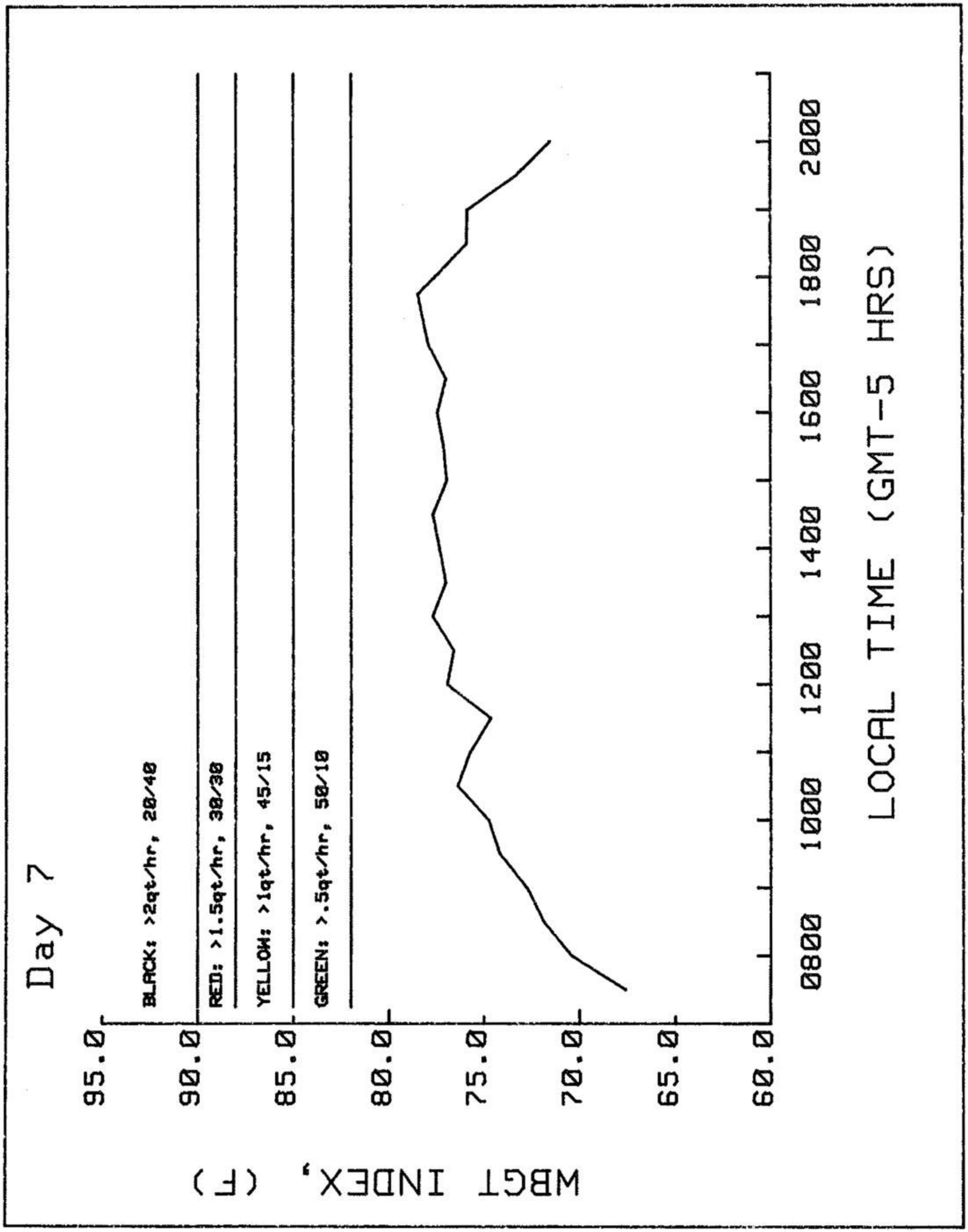


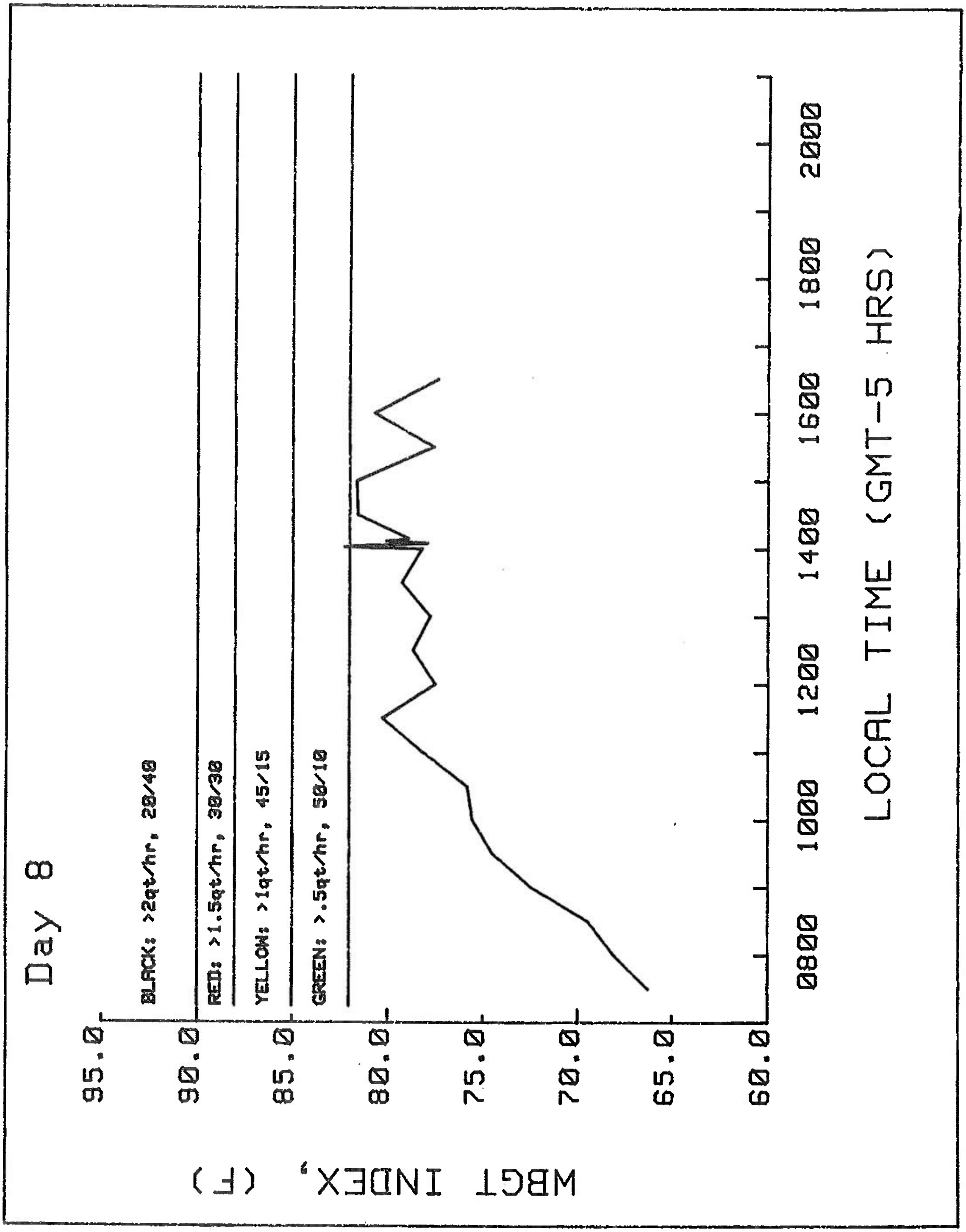
Day 3
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
WBGT INDEX, (F)
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)


Day 4
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
WBGT INDEX, (F)
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)


Day 5
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
WBGT INDEX, (F)
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)


Day 6
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
WBGT INDEX, (F)
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)


Day 7
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
WBGT INDEX, (F)
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)



Day 8
BLACK: >2qt/hr, 20/40
RED: >1.5qt/hr, 30/30
YELLOW: >1qt/hr, 45/15
GREEN: >.5qt/hr, 50/10
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
WBGT INDEX, (F)
0800
1000
1200
1400
1600
1800
2000
LOCAL TIME (GMT-5 HRS)

APPENDIX D - FLUID INTAKE/BETWEEN MEAL FOOD DATA COLLECTION FORM

ID NUMBER ______ DAY NUMBER ______

MRE RATION CONSUMPTION

Circle the amount that indicates how much of each item you ate today. If the appropriate number is not listed, write it on the line provided. For example: If you eat 2 beef stew entrees, circle 2. If you drink 2 1/2 canteen cups of coffee, write in "2 1/2".

ADDED WATER

Please list the amount of water you added to each food or beverage item that you ate. Write in "0" if you did not add water to an item that you consumed.

FOOD ITEM	CODE	AMOUNT CONSUMED (by package)						WATER (in canteen cups) i.e., 1/4, 1/2, 3/4, etc.
BEEF W/BBQ SCE		1/4	1/2	3/4	1	2		
BEEF W/GRAVY		1/4	1/2	3/4	1	2		
BEEF W/SPICED SCE		1/4	1/2	3/4	1	2		
BEEF PATTIES		1/4	1/2	3/4	1	2		
BEEF STEW		1/4	1/2	3/4	1	2		
CHICKEN A LA KING		1/4	1/2	3/4	1	2		
FRANKFURTERS		1/4	1/2	3/4	1	2		
HAM SLICE		1/4	1/2	3/4	1	2		
HAM/CHICKEN LOAF		1/4	1/2	3/4	1	2		
MEATBALLS W/BBQ SCE		1/4	1/2	3/4	1	2		
PORK SAUSAGE PATTIES		1/4	1/2	3/4	1	2		
TURKEY W/GRAVY		1/4	1/2	3/4	1	2		
CRACKERS		1/4	1/2	3/4	1	2		
POTATO PATTY		1/4	1/2	3/4	1	2		
BEANS w/TOMATO SCE		1/4	1/2	3/4	1	2		
CHEESE		1/4	1/2	3/4	1	2		
JELLY		1/4	1/2	3/4	1	2		
PEANUT BUTTER		1/4	1/2	3/4	1	2		
APPLESAUCE		1/4	1/2	3/4	1	2		
FRUIT MIX		1/4	1/2	3/4	1	2		
PEACHES		1/4	1/2	3/4	1	2		
STRAWBERRIES		1/4	1/2	3/4	1	2		
CHOC CVD BROWNIE		1/4	1/2	3/4	1	2		
CHERRY NUT CAKE		1/4	1/2	3/4	1	2		
CHOC CVD COOKIE BAR		1/4	1/2	3/4	1	2		
CHOC NUT CAKE		1/4	1/2	3/4	1	2		
MAPLE NUT CAKE		1/4	1/2	3/4	1	2		
FRUITCAKE		1/4	1/2	3/4	1	2		
ORANGE NUT CAKE		1/4	1/2	3/4	1	2		
PINEAPPLE NUT CAKE		1/4	1/2	3/4	1	2		
COCOA POWDER		1/4	1/2	3/4	1	2		
COFFEE		1/4	1/2	3/4	1	2		
CREAM SUBSTITUTE		1/4	1/2	3/4	1	2		
SUGAR		1/4	1/2	3/4	1	2		
CATSUP		1/4	1/2	3/4	1	2		
GRAVY BASE (SOUP MIX)		1/4	1/2	3/4	1	2		
CANDY (ALL TYPES)		1/4	1/2	3/4	1	2		
GUM		1/4	1/2	3/4	1	2		
SALT		1/4	1/2	3/4	1	2		

NATICK Form 705 (ONE-TIME)
1 May 88

REASONS DID NOT EAT/FINISH

Write in the number of the PRIMARY REASON that you didn't finish an item or did not eat the item at all. If your PRIMARY REASON is not listed, write it in.

1 Spilled	7 Unable to heat
2 Feel full	8 Not enough water
3 Too salty	9 Tasted bad
4 Dieting	10 Smelled bad
5 Saved	11 Feel Sick
6 Traded	12 Not enough time

BEEF W/BBQ SCE	
BEEF W/GRAVY	
BEEF W/SPICED SCE	
BEEF PATTIES	
BEEF STEW	
CHICKEN A LA KING	
FRANKFURTERS	
HAM SLICE	
HAM/CHICKEN LOAF	
MEATBALLS W/BBQ SCE	
PORK SAUSAGE PATTIES	
TURKEY W/GRAVY	
CRACKERS	
POTATO AU GRATIN	
BEANS w/TOMATO SCE	
CHEESE	
JELLY	
PEANUT BUTTER	
APPLE SAUCE	
FRUIT MIX	
PEACHES	
STRAWBERRIES	
CHOC COV BROWNIE	
CHERRY NUT CAKE	
CHOC COV COOKIE BAR	
CHOCOLATE NUT CAKE	
MAPLE NUT CAKE	
FRUITCAKE	
ORANGE NUT CAKE	
PINEAPPLE NUT CAKE	
COCOA POWDER	
COFFEE	
CREAM SUBSTITUTE	
SUGAR	
CATSUP	
GRAVY BASE (SOUP MIX)	
CANDY (ALL TYPES)	
GUM	
SALT	

FLUID INTAKE DATA COLLECTION FORM
for period from 0500-0500 hours

HOUR FILLED:	AMOUNT (3/4, full, etc) PUT IN CANTEEN:	THROWN AWAY:	CIRCLE TYPE OF FLUID IN CANTEEN. SPECIFY IF OTHER:		
____	________	________	Plain Water	Test Beverage	Other:________
____	________	________	Plain Water	Test Beverage	Other:________
____	________	________	Plain Water	Test Beverage	Other:________
____	________	________	Plain Water	Test Beverage	Other:________
____	________	________	Plain Water	Test Beverage	Other:________
____	________	________	Plain Water	Test Beverage	Other:________
____	________	________	Plain Water	Test Beverage	Other:________

****

ACCEPTABILITY RATING - We would like your opinion of the test beverage you were given to drink between meals. Circle the rating that best describes your opinion. (If you had only water to drink between meals, rate water.)

DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
1	2	3	4	5	6	7	8	9

****

BETWEEN-MEAL SNACKS

HOUR	AMOUNT	DESCRIPTION
ie: 0800 hr	1-12 oz can	Coke
1600 hr	2.16 oz	Snickers Bar

APPENDIX E - FLUID INTAKE NORMALIZED TO BODY WEIGHT

SUMMARY STATISTICS FOR VARIATE(S):

VARIATE	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DEP_VAR	440	62.25	1.291	27.09	62.39	165.4	6.480

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
GROUP	A	104	59.6855	2.4081	24.5577	59.9350	133.5200	10.9300
	B	120	58.0669	2.5167	27.5689	59.3673	160.9200	6.4800
	C	88	63.9289	2.5315	23.7472	62.8578	139.6000	10.0700
	D	128	67.1101	2.6537	30.0227	67.3812	165.3500	10.1700
SEX	MALE	216	67.0012	1.7647	25.9355	67.2249	165.3500	10.0700
	FEMALE	224	57.6736	1.8337	27.4446	57.5457	160.9200	6.4800
DAY	* 1.0000	55	66.6907	4.0187	29.8038	65.9093	158.9500	14.7100
	* 2.0000	55	67.3544	4.0030	29.6870	67.8221	139.6000	26.7200
	* 3.0000	55	65.1904	3.8540	28.5818	65.3339	165.3500	10.0700
	* 4.0000	55	72.5247	3.6575	27.1251	72.9356	147.5300	10.1700
	* 5.0000	55	49.4131	2.6760	19.8461	49.5497	94.9500	10.3700
	* 6.0000	55	64.3965	3.3593	24.9131	65.0012	126.3100	17.2400
	* 7.0000	55	56.9525	3.6707	27.2225	56.8006	160.9200	6.4800
	* 8.0000	55	55.4985	2.9463	21.8502	55.7301	115.2800	11.6100

GROUP ARMYADE

==>
SEX MALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	6	53.4683	6.5991	16.1643	53.4683	79.3500	31.3400
	* 2.0000	6	61.8450	13.9497	34.1697	61.8450	125.8700	37.5500
	* 3.0000	6	71.0383	4.3479	10.6500	71.0383	80.5400	53.2100
	* 4.0000	6	75.4583	13.3711	32.7524	75.4583	133.5200	38.7600
	* 5.0000	6	49.2333	9.3260	22.8439	49.2333	79.5400	10.9300
	* 6.0000	6	65.6800	7.3608	18.0302	65.6800	88.3400	44.2700
	* 7.0000	6	65.5067	7.2908	17.8587	65.5067	87.3000	40.9600
	* 8.0000	6	63.1967	8.9340	21.8838	63.1967	97.7200	36.8900

==>
SEX FEMALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	7	48.0843	8.2763	21.8970	48.0843	76.1300	14.7100
	* 2.0000	7	65.9800	9.5157	25.1761	65.9800	102.8200	41.9500
	* 3.0000	7	60.7843	10.7270	28.3809	60.7843	97.5000	33.6800
	* 4.0000	7	61.6229	8.6755	22.9533	61.6229	87.3800	26.6600
	* 5.0000	7	52.8800	8.2514	21.8312	52.8800	94.9500	32.3300
	* 6.0000	7	71.5257	15.0599	39.8448	71.5257	126.3100	22.5200
	* 7.0000	7	41.4243	4.0221	10.6416	41.4243	61.0300	29.8300
	* 8.0000	7	51.2314	9.7725	25.8556	51.2314	91.3700	13.8500

GROUP CONTROL

==>
SEX MALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	6	69.5217	7.9289	19.4218	69.5217	90.6800	37.9900
	* 2.0000	6	76.5867	11.8862	29.1152	76.5867	105.2200	36.7100
	* 3.0000	6	73.4267	8.3231	20.3875	73.4267	106.2400	48.2500
	* 4.0000	6	76.4133	7.7065	18.8770	76.4133	109.8100	57.4600
	* 5.0000	6	50.0133	8.1817	20.0409	50.0133	81.7900	26.9500
	* 6.0000	6	61.3850	11.6105	28.4399	61.3850	106.3300	29.1000
	* 7.0000	6	56.7233	8.0155	19.6338	56.7233	82.3700	25.4400
	* 8.0000	6	62.8833	8.4666	20.7388	62.8833	91.2300	42.5500

==>
SEX FEMALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	9	65.2022	11.0272	33.0815	65.2022	127.8000	30.4900
	* 2.0000	9	57.0489	13.1868	39.5604	57.0489	131.1200	26.7200
	* 3.0000	9	52.3744	6.8049	20.4147	52.3744	86.0200	31.2800
	* 4.0000	9	65.7022	10.9278	32.7833	65.7022	130.4000	23.1000
	* 5.0000	9	41.6033	6.2063	18.6188	41.6033	77.3900	15.4300
	* 6.0000	9	47.4856	6.0806	18.2419	47.4856	74.7300	26.4900
	* 7.0000	9	49.6044	15.2125	45.6376	49.6044	160.9200	6.4800
	* 8.0000	9	43.9022	3.6497	10.9491	43.9022	60.8500	29.0900

===

GROUP PLACEBO

==>
SEX MALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	6	77.8183	5.3135	13.0155	77.8183	92.6700	56.4700
	* 2.0000	6	90.3150	12.7958	31.3432	90.3150	139.6000	48.0300
	* 3.0000	6	73.5483	16.8250	41.2126	73.5483	110.1500	10.0700
	* 4.0000	6	80.0400	4.9540	12.1349	80.0400	95.8400	62.0100
	* 5.0000	6	54.4433	4.4070	10.7949	54.4433	63.8700	40.2300
	* 6.0000	6	82.8667	5.0076	12.2662	82.8667	100.5200	63.4700
	* 7.0000	6	72.6017	8.4889	20.7934	72.6017	92.5400	35.8600
	* 8.0000	6	85.4867	4.2908	10.5104	85.4867	79.6100	51.1100

==>
SEX FEMALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	5	58.4480	7.0735	15.8169	58.4480	85.4900	46.3000
	* 2.0000	5	48.6080	6.1793	13.8174	48.6080	66.8800	37.3900
	* 3.0000	5	44.9140	6.5871	14.7292	44.9140	62.9000	23.3000
	* 4.0000	5	70.0340	8.2858	18.5277	70.0340	90.7400	50.0700
	* 5.0000	5	39.3360	4.4820	10.0220	39.3360	55.4700	28.0600
	* 6.0000	5	59.5220	7.0238	15.7056	59.5220	78.6400	36.3400
	* 7.0000	5	44.0180	9.5085	21.2616	44.0180	73.0900	14.5700
	* 8.0000	5	43.7240	9.3694	20.9505	43.7240	68.8100	18.6800

==

GROUP NBC

==>
SEX MALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	9	82.1844	14.5158	43.5475	82.1844	158.9500	43.6500
	* 2.0000	9	59.1589	7.0320	21.0960	59.1589	90.3100	27.3700
	* 3.0000	9	64.9322	13.9730	41.9189	64.9322	165.3500	28.5600
	* 4.0000	9	72.5200	8.9923	26.9770	72.5200	102.4300	25.5900
	* 5.0000	9	46.0467	8.2928	24.8784	46.0467	90.6500	10.3700
	* 6.0000	9	67.8744	5.7470	17.2411	67.8744	89.3500	42.2400
	* 7.0000	9	67.6067	9.5666	28.6999	67.6067	117.4500	30.5300
	* 8.0000	9	61.3733	11.0163	33.0489	61.3733	115.2800	11.6100

==>
SEX FEMALE
====>

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	7	72.5471	14.7193	38.9436	72.5471	151.4800	29.6600
	* 2.0000	7	83.0343	8.5179	22.5362	83.0343	108.0000	44.3300
	* 3.0000	7	81.6529	8.8437	23.3981	81.6529	114.2700	52.4300
	* 4.0000	7	81.6943	15.8445	41.9205	81.6943	147.5300	10.1700
	* 5.0000	7	62.8414	7.5960	20.0972	62.8414	89.3900	29.1500
	* 6.0000	7	63.6700	12.2176	32.3247	63.6700	114.2500	17.2400
	* 7.0000	7	56.9200	7.9485	21.0297	56.9200	88.4400	32.2700
	* 8.0000	7	54.0429	6.1383	16.2403	54.0429	81.9600	35.1700

```
EFFECT   VARIATE        STATISTIC               F          DF          P
-------------------------------------------------------------------------
 OVALL: GRAND MEAN
        DEP_VAR
                  SS=      1.6496450E+6
                  MS=      1.6496450E+6      712.32      1,     47  0.0000
 G: GROUP
        DEP_VAR
                  SS=       4823.104873
                  MS=       1607.701624        0.69      3,     47  0.5602
 S: SEX
        DEP_VAR
                  SS=       9927.561971
                  MS=       9927.561971        4.29      1,     47  0.0439
 GS
        DEP_VAR
                  SS=      10832.169178
                  MS=       3610.723059        1.56      3,     47  0.2118

 ERROR
        DEP_VAR
                  SS=     108846.53835987
                  MS=       2315.88379489

-------------------------------------------------------------------------
```

```
=====================================================================
WITHIN EFFECT: D: DAY

EFFECT   VARIATE       STATISTIC                  F         DF          P
---------------------------------------------------------------------
 D
       DEP_VAR
                 TSQ=      42.4799             5.29      7,     41  Ø.ØØØ2
             WCP SS=     21673.Ø63818
             WCP MS=      3Ø96.151974          6.85      7,    329  Ø.ØØØØ
             GREENHOUSE-GEISSER ADJ. DF        6.85   5.25, 246.68  Ø.ØØØØ
             HUYNH-FELDT ADJUSTED DF           6.85   6.87, 322.71  Ø.ØØØØ
 (D) X (G: GROUP)
       DEP_VAR
                 LRATIO=  Ø.739372             Ø.62     21, 118.28  Ø.8935
                 TRACE=   Ø.322892
                 TZSQ=     13.8844
                     CHISQ =     4.87                         9.924  Ø.8965
                 MXROOT=  Ø.152817                                   Ø.6612
             WCP SS=      6661.575728
             WCP MS=       317.217892          Ø.7Ø     21,    329  Ø.8316
             GREENHOUSE-GEISSER ADJ. DF        Ø.7Ø  15.75, 246.68  Ø.7891
             HUYNH-FELDT ADJUSTED DF           Ø.7Ø  2Ø.6Ø, 322.71  Ø.8288
 (D) X (S: SEX)
       DEP_VAR
                 TSQ=       9.65427            1.2Ø      7,     41  Ø.3229
             WCP SS=      2459.769757
             WCP MS=       351.39568Ø          Ø.78      7,    329  Ø.6Ø68
             GREENHOUSE-GEISSER ADJ. DF        Ø.78   5.25, 246.68  Ø.5726
             HUYNH-FELDT ADJUSTED DF           Ø.78   6.87, 322.71  Ø.6Ø45
 (D) X (GS)
       DEP_VAR
                 LRATIO=  Ø.647Ø43             Ø.92     21, 118.28  Ø.5638
                 TRACE=   Ø.482677
                 TZSQ=     2Ø.7551
                     CHISQ =     8.62                         9.924  Ø.5619
                 MXROOT=  Ø.227397                                   Ø.5398
             WCP SS=      7918.445763
             WCP MS=       377.Ø68846          Ø.83     21,    329  Ø.6772
             GREENHOUSE-GEISSER ADJ. DF        Ø.83  15.75, 246.68  Ø.6445
             HUYNH-FELDT ADJUSTED DF           Ø.83  2Ø.6Ø, 322.71  Ø.6749

 ERROR
       DEP_VAR
             WCP SS=    148747.25251756
             WCP MS=       452.1193Ø856

             GGI EPSILON      Ø.7498Ø
             H-F EPSILON      Ø.98Ø88
```

APPENDIX F - RATIO OF TEST BEVERAGE TO TOTAL FLUID CONSUMPTION

APPENDIX

Ratio of test beverage to total quantity of fluids consumed.

DAY	GROUPS			
	ARMYADE (n=13)	CONTROL (n=15)	PLACEBO (n=11)	NBC (n=16)
1	0.61±0.07	0.69±0.04	0.77±0.06	0.56±0.06
2	0.52±0.06	0.54±0.06	0.50±0.08	0.46±0.07
3	0.43±0.06	0.59±0.05	0.61±0.08	0.50±0.07
4	0.53±0.06	0.64±0.05	0.70±0.02	0.48±0.07
5	0.34±0.08	0.46±0.08	0.47±0.09	0.44±0.05
6	0.42±0.06	0.60±0.05	0.70±0.07	0.48±0.07
7	0.48±0.07	0.58±0.08	0.69±0.04	0.42±0.08
8	0.49±0.09	0.58±0.05	0.52±0.08	0.41±0.08

APPENDIX G - SAMPLE OF POST-SCENARIO ACCEPTABILITY QUESTIONNAIRE

FINAL QUESTIONNAIRE

We would like your opinions about the beverages that you drank last week. Your answers will be kept confidential. Please answer honestly and thoughtfully.

Use a No. 2 pencil when filling in the circles. Completely erase any changes or stray marks. THANK YOU.

Proper Mark

USE A NO.2 PENCIL

Please indicate your test identification letter and number. ____________________

DO NOT WRITE IN THIS BOX

1. What is your rank?

	1	2	3	4	5	6	7	8	9
E	○	○	○	○	○	○	○	○	○
O	○	○	○	○	○	○	○	○	○
WO	○	○	○	○					

2. What is your age?
- ○ under 18
- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55+

3. How long have you been in the Armed Services? Fill in one answer.
- ○ 0-5 years
- ○ 6-10 years
- ○ 11-15 years
- ○ 16-20 years
- ○ More than 20 years

4. What is your height?
________FT ________IN

DO NOT WRITE IN THIS BOX

5. What is your weight? ____________ lbs

DO NOT WRITE IN THIS BOX

6. What is your sex?
- ○ Male
- ○ Female

7. Were you trying to lose weight during the study? ○ YES ○ NO

8. Were you trying to gain weight during this study? ○ YES ○ NO

9. Rate how much you like/dislike the water you drank last week.

NEVER TRIED	DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
0	1	2	3	4	5	6	7	8	9

10. How would you describe the temperature of the drink or water in your canteen during most of the exercise?

COLD	MODERATELY COOL	SLIGHTLY COOL	NEUTRAL	SLIGHTLY WARM	MODERATELY WARM	HOT
1	2	3	4	5	6	7

11. How would you describe the temperature of drinks (milk, juice, etc.) served with breakfast? Do not rate hot drinks (coffee, cocoa, etc.).

COLD	MODERATELY COOL	SLIGHTLY COOL	NEUTRAL	SLIGHTLY WARM	MODERATELY WARM	HOT
1	2	3	4	5	6	7

12. How would you describe the temperature of the beverages (Kool Aid, juice, etc.) served with the evening meal? Do not rate hot drinks (coffee, cocoa, etc.).

COLD	MODERATELY COOL	SLIGHTLY COOL	NEUTRAL	SLIGHTLY WARM	MODERATELY WARM	HOT
1	2	3	4	5	6	7

13. Did you drink as much as you wanted/needed during the exercise?

YES NO

IF YES, SKIP TO QUESTION 16.

14. Why did you not drink as much as you wanted/needed during the exercise? Fill in a circle for all that apply.

DO NOT WRITE IN BOX

a. Pick-up water was too far
b. No beverage powders (Kool Aid,etc.) available
c. Not enough beverage powders (Kool Aid, etc.)
d. Did not like beverages provided
e. Water/beverage in canteen got too warm
f. Pick-up water too warm
g. Pick-up water had a bad taste
h. Not enough time to drink
i. Tried to drink less to avoid bathroom
j. Tried to lose weight
k. other (please explain)____________________________

6401

15. If you circled more than one reason in question 14, fill in one circle for the most frequent reason.

◯ a ◯ b ◯ c ◯ d ◯ e ◯ f ◯ g ◯ h ◯ i ◯ j ◯ k

16. What commercial (brand name) beverages did you drink during the exercise? Please list all beverages and amounts. If you did not drink any commercial beverages fill in this circle. ◯

Beverage	Average amount per day
______	______
______	______
______	______
______	______

17. Did you eat as much as you wanted/needed during this exercise?

◯ YES ◯ NO

IF YES, SKIP TO QUESTION 20.

18. Why did you not eat as much as you wanted/needed during the exercise? Fill in a circle for all that apply.

DO NOT WRITE IN BOX

- ◯ a. Disliked the food in the MRE
- ◯ b. Disliked the food in A rations
- ◯ c. Portions too small in MRE
- ◯ d. Portions too small in A rations
- ◯ e. Not enough time to prepare the MRE
- ◯ f. Too much trouble to prepare the MRE
- ◯ g. Not enough time to eat
- ◯ h. Could not heat the MRE
- ◯ i. A ration food was not hot enough
- ◯ j. Not enough water to prepare the MRE
- ◯ k. Got bored with the food
- ◯ l. Felt too constipated
- ◯ m. Felt too sick
- ◯ n. Felt too tired
- ◯ o. Felt too hot
- ◯ p. Felt too thirsty
- ◯ q. Trying to lose weight
- ◯ r. other (please explain) ______

19. If you circled more than one reason in question 18, fill in one circle for the most frequent reason.

◯ a ◯ b ◯ c ◯ d ◯ e ◯ f ◯ g ◯ h ◯ i

◯ j ◯ k ◯ l ◯ m ◯ n ◯ o ◯ p ◯ q ◯ r

20. How often were you hungry during the exercise?

NEVER	ALMOST NEVER	SOMETIMES	FAIRLY OFTEN	OFTEN	ALMOST ALWAYS	ALWAYS
1	2	3	4	5	6	7
◯	◯	◯	◯	◯	◯	◯

21. How often were you thirsty during the exercise?

NEVER	ALMOST NEVER	SOMETIMES	FAIRLY OFTEN	OFTEN	ALMOST ALWAYS	ALWAYS
1	2	3	4	5	6	7
◯	◯	◯	◯	◯	◯	◯

22. How much experience do you have living/working in a very hot climate?

◯ No experience before last week
◯ Slightly experienced (one or two field exercises or visits to very hot areas)
◯ Moderately experienced (lived up to 6 months in a very hot climate)
◯ Very experienced (lived 6 months or more in a very hot climate)

23. Have you ever had any of the following?

	YES	NO
Heat exhaustion	◯	◯
Dehydration	◯	◯
Heat stroke	◯	◯
Heat cramps	◯	◯

24. Have you ever drunk any electrolyte/sports drinks (like Gatorade) before this past week? ◯ YES ◯ NO

IF NO, GO TO QUESTION 26

25. What is your favorite commercial sports/electrolyte drink? ____________________

DO NOT WRITE IN THIS BOX ◯◯◯◯◯◯◯◯◯

25a. Please rate how much you like/dislike this sports electrolyte drink.

DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
1	2	3	4	5	6	7	8	9
◯	◯	◯	◯	◯	◯	◯	◯	◯

26. Have you ever drunk beverages with "Nutrasweet" Sweetener in them?

◯ Yes
◯ No (skip to question 27)
◯ Don't know (skip to question 27)

26a. How would you rate the taste of "Nutrasweet" sweetened beverages?

DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
1	2	3	4	5	6	7	8	9
◯	◯	◯	◯	◯	◯	◯	◯	◯

27. If you had 2 canteens with you in the field, which would you prefer to carry in a hot climate? Fill in only one circle.

DO NOT WRITE IN THIS BOX

- ◯ 2 canteens of water
- ◯ 2 canteens of test beverage
- ◯ 1 canteen water, 1 canteen test beverage
- ◯ 2 canteens Kool Aid drink
- ◯ 1 canteen water, 1 canteen Kool Aid drink
- ◯ 2 canteens Gatorode
- ◯ 1 canteen water, 1 canteen Gatorade
- ◯ other ____________________

28. If you had only 1 canteen with you in the field, which would you prefer to carry in a hot climate? Fill in only one circle.

- ◯ Water
- ◯ Test beverage
- ◯ Kool Aid
- ◯ Gatorade
- ◯ Lemonade
- ◯ Juice ____________________ (write in)
- ◯ Carbonated beverage (soda) ____________________ (write in)
- ◯ Other ____________________ (write in)

ANSWER THE REST OF THE QUESTIONNAIRE ONLY IF YOU WERE IN ONE OF THE TEST BEVERAGE GROUPS DURING THE WEEK.

29. We would like your opinion of the test beverage you were given to drink last week. Using the scale below, fill in the circle that best describes how much you like/dislike the drink.

NEVER TRIED	DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE NOR DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY
0	1	2	3	4	5	6	7	8	9
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

30. How sweet was the test drink?

NOT AT ALL SWEET	SLIGHTLY SWEET	SOMEWHAT SWEET	MODERATELY SWEET	VERY SWEET	EXTREMELY SWEET
1	2	3	4	5	6
◯	◯	◯	◯	◯	◯

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31. What do you think about the amount of sweetness in the drink?

MUCH TOO LITTLE	MODERATELY TOO LITTLE	SOMEWHAT TOO LITTLE	JUST RIGHT	SOMEWHAT TOO MUCH	MODERATELY TOO MUCH	MUCH TOO MUCH
1	2	3	4	5	6	7

32. How salty was the test drink?

NOT AT ALL SALTY	SLIGHTLY SALTY	SOMEWHAT SALTY	MODERATELY SALTY	VERY SALTY	EXTREMELY SALTY
1	2	3	4	5	6

33. What do you think about the amount of saltiness in the drink?

MUCH TOO LITTLE	MODERATELY TOO LITTLE	SOMEWHAT TOO LITTLE	JUST RIGHT	SOMEWHAT TOO MUCH	MODERATELY TOO MUCH	MUCH TOO MUCH
1	2	3	4	5	6	7

34. Was there an "aftertaste"?

NO AFTERTASTE	SLIGHT AFTERTASTE	MODERATE AFTERTASTE	LARGE AFTERTASTE	VERY LARGE AFTERTASTE
1	2	3	4	5

35. Were you issued an appropriate amount of test drink each day?

NEEDED MUCH LESS	NEEDED MODERATELY LESS	NEEDED SLIGHTLY LESS	AMOUNT JUST RIGHT	NEEDED SLIGHTLY MORE	NEEDED MODERATELY MORE	NEEDED MUCH MORE
1	2	3	4	5	6	7

36. Compared to water, did your test drink give you more energy?

DO NOT KNOW	NO ADDITONAL ENERGY	SLIGHTLY MORE ENERGY	SOMEWHAT MORE ENERGY	MODERATELY MORE ENERGY	MUCH MORE ENERGY
0	1	2	3	4	5

37. Compared to water, do you think your test drink was better or worse at replacing body fluids lost by sweat?

Compared to water the drink was:

DO NOT KNOW	MUCH WORSE	MODERATELY WORSE	SLIGHTLY WORSE	NOT BETTER OR WORSE	SLIGHTLY BETTER	MODERATELY BETTER	MUCH BETTER
0	1	2	3	4	5	6	7

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38. Would you buy the test drink if you were going to be exercising or working in the heat?

- ◯ No, definitely not
- ◯ Possibily
- ◯ Probably
- ◯ Yes, definitely

39. Would you buy Gatorade or another commercial sports drink if you were going to be exercising or working in the heat?

- ◯ No, definitely not
- ◯ Possibly
- ◯ Probably
- ◯ Yes, definitely

40. What did you like about the test drink you were issued last week?

41. How could the test drink be improved?

APPENDIX H - RATION RECORD FORM

RATION RECORD

NAME: ________________ DATA COLLECTOR # ________

SUBJECT #: ________________ DATA ENTERER # ________

JULIAN DATE: 85________

MEAL: (CIRCLE ONE)

BREAKFAST - B

DINNER - D

RATION TYPE: (CIRCLE ONE)

A B T

FOOD TYPE	DESCRIPTION	CODE #	REASON NOT EATEN CODE	PORTION SERVED	PORTION RETURNED	RATING CODE
ENTREE						
VEGETABLE						
STARCH						
FRUIT						
BREAD						
SPREAD						
DESSERT						
BEVERAGE						
OTHER						

NATICK Form 613 (ONE-TIME)
1 Jul 85

APPENDIX I - MISSING DATA

NUMBER OF FLUID INTAKE/BETWEEN MEAL FOOD FORMS

MISSING PER SUBJECT

NUMBER OF FLUID INTAKE FORMS MISSING	NUMBER OF SUBJECTS (n=61)
0	39
1	15
2	2
3	3
4	2
5	-
6	-
7	-
8	-
9	-
10	-
11	-
12	-
13	-
14	-
15	-

NOTE: Fluid intake forms were collected two times a day (except Day 5 when only one form was collected) for 8 days and therefore the maximum number of forms that could be collected was 15.

APPENDIX

FOOD SERVICE MEALS SKIPPED BY EACH SUBJECT

SUBJECT NUMBER	GROUPS (n=61)			
	ARMYADE	CONTROL	PLACEBO	NBC
1	-	0	0	2
2	15	-	5	3
3	1	2	2	0
4	1	3	2	3
5	-	1	-	0
6	0	-	1	4
7	-	2	0	1
8	1	1	-	0
9	3	-	-	-
10	3	0	0	0
11	6	-	-	-
12	0	-	-	1
13	11	2	2	1
14	1	-	5	1
15	-	3	0	-
16	-	7	0	0
17	0	1	4	1
18	-	2	2	2
19	1	3	-	6
20	0	3	-	-
21	-	3	-	3
22	1	-	-	-
23	-	-	-	0

MISSING FLUID INTAKE/BETWEEN MEAL FOOD DATA FOR EACH SUBJECT

SUBJECT NUMBER	GROUP			
	ARMYADE	CONTROL	PLACEBO	NBC
1	-	0	0	0
2	1	-	0	0
3	0	1	0	0
4	0	0	0	0
5	-	1	-	0
6	1	-	1	0
7	-	0	0	0
8	0	1	-	1
9	2	-	-	-
10	0	0	1	1
11	0	-	-	-
12	1	-	-	0
13	2	4	0	3
14	1	-	0	1
15	-	0	0	-
16	-	0	0	1
17	0	0	1	0
18	-	0	0	0
19	4	0	-	3
20	3	1	-	-
21	-	0	-	0
22	0	-	-	-
23	-	-	-	0

FOOD SERVICE MEALS SKIPPED PER DAY[a]

DAY	ARMYADE AM	ARMYADE PM	CONTROL AM	CONTROL PM	PLACEBO AM	PLACEBO PM	NBC AM	NBC	TOTAL PM	TOTAL AM	TOTAL PM	PERCENT AM/PM
1	2	2	3	0	2	2	1	2	8	6	14	11
2	2	1	0	2	0	1	0	1	2	5	7	6
3	5	2	2	2	2	3	4	0	13	7	20	16
4	6	3	4	2	0	2	1	1	11	8	19	15
5	3	5	2	5	3	2	1	6	9	18	27	22
6	3	2	3	0	2	0	1	2	9	4	13	11
7	2	3	5	1	1	0	3	1	11	5	16	14
8	1	2	2	0	2	1	3	1	8	4	12	11
TOTAL											128	13

[a]Meals served by food service (breakfast and dinner) were not eaten but data were collected on sustitute foods on a Fluid Intake/Between Meal Food Data Collection Form.

MISSING FLUID INTAKE/BETWEEN MEAL FOOD DATA PER DAY

	GROUPS											
	ARMYADE		CONTROL		PLACEBO		NBC					
DAY	AM	PM	AM	PM	AM	PM	AM	PM	TOTAL AM	TOTAL PM	TOTAL AM/PM	PERCENT %
1	1	2	1	0	0	0	0	0	2	2	4	3
2	0	0	0	1	0	0	2	0	2	1	3	2
3	0	2	1	0	0	1	1	0	2	3	5	4
4	1	0	2	0	0	0	1	1	4	1	5	4
5	1	-	0	-	0	-	1	-	2	-	2	3
6	0	1	0	1	0	1	0	2	0	5	5	4
7	2	2	1	1	0	1	0	0	3	4	7	6
8	0	2	0	1	0	0	0	2	0	5	5	5
TOTAL											36	4

APPENDIX J - MEAN NUTRIENT INTAKE BY GROUP AND GENDER

POOLED MALES
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 208.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	6547.094	162.847	2348.616	1808.80	14450.19	1361795.451	208	
ENERGY	3055.691	73.762	1063.809	597.54	5944.03	635583.778	208	
PROTEIN	113.076	3.117	44.951	9.58	302.70	23519.736	208	
CARBOHYD	403.532	10.844	156.401	54.95	799.21	83934.701	208	
FAT	112.079	3.037	43.798	5.24	228.72	23312.355	208	
CHOLESTR	581.438	22.084	318.506	15.98	1470.54	120939.011	208	
THIAMIN	2.589	.089	1.276	.18	7.12	538.470	208	
RIBOFLAV	2.692	.082	1.176	.33	7.82	559.882	208	
NIACIN	28.205	.810	11.679	4.59	67.76	5866.707	208	
VITC	167.517	9.587	138.269	8.77	652.76	34843.593	208	
VITB6	2.130	.077	1.117	.31	6.44	442.984	208	
VITB12	4.338	.186	2.687	.00	14.87	902.227	208	
VITA	1088.364	47.888	690.651	28.35	3988.30	226379.776	208	
IRON	18.593	.490	7.062	1.80	52.42	3867.337	208	
CALCIUM	1416.712	43.947	633.810	111.60	4074.28	294676.045	208	
MAGNESUM	406.801	15.666	225.941	52.35	1146.42	84614.556	208	
PHOSPHOR	2016.822	56.668	817.276	211.44	4913.94	419498.960	208	
SODIUM	5005.903	128.262	1849.825	402.13	10743.43	1041227.756	208	
POTASIUM	3879.251	109.489	1579.072	673.71	8306.92	806884.231	208	
FOLACIN	261.854	9.011	129.954	.00	832.07	54465.732	208	
ZINC	11.661	.365	5.261	.43	30.94	2425.458	208	

POOLED FEMALES
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 232.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	4828.015	130.993	1995.233	600.98	12514.95	1120099.512	232	
ENERGY	2343.106	54.767	834.190	136.70	6162.47	543600.496	232	
PROTEIN	82.385	3.116	47.460	.00	535.20	19113.394	232	
CARBOHYD	327.808	7.919	120.619	34.75	758.58	76051.544	232	
FAT	80.251	2.457	37.424	.00	277.14	18618.339	232	
CHOLESTR	457.195	19.546	297.718	.00	1552.71	106069.242	232	
THIAMIN	1.926	.072	1.102	.00	5.92	446.720	232	
RIBOFLAV	2.011	.067	1.016	.00	8.71	466.470	232	
NIACIN	21.987	.836	12.731	.00	112.92	5100.954	232	
VITC	172.041	9.773	148.863	.00	907.95	39913.509	232	
VITB6	1.692	.068	1.038	.00	6.11	392.595	232	
VITB12	3.485	.168	2.565	.00	20.28	808.604	232	
VITA	916.140	42.696	650.328	.00	3658.76	212544.432	232	
IRON	14.059	.463	7.051	.29	71.62	3261.762	232	
CALCIUM	1035.562	35.081	534.338	62.03	5631.21	240250.390	232	
MAGNESUM	286.206	8.399	127.937	42.18	920.69	66399.728	232	
PHOSPHOR	1488.273	41.552	632.897	57.26	5397.67	345279.263	232	
SODIUM	3529.320	110.728	1686.565	230.55	11633.95	818802.200	232	
POTASIUM	2891.873	86.485	1317.307	189.96	9360.76	670914.525	232	
FOLACIN	243.682	8.576	130.633	.00	833.58	56534.308	232	
ZINC	10.419	.929	14.145	.29	127.33	2417.284	232	

GROUP: ARMYADE SEX: MALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 48.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	6172.002	281.646	1951.300	1878.60	10264.60	296256.090	48	
ENERGY	3540.306	119.026	824.636	1539.98	5089.22	169934.679	48	
PROTEIN	134.068	5.053	35.008	61.40	243.78	6435.267	48	
CARBOHYD	473.751	18.665	129.314	229.04	759.30	22740.056	48	
FAT	126.835	5.658	39.199	41.88	221.22	6088.100	48	
CHOLESTR	646.075	38.707	268.171	107.95	1339.55	31011.605	48	
THIAMIN	2.916	.160	1.110	.77	6.59	139.948	48	
RIBOFLAV	3.058	.102	.705	.91	4.87	146.798	48	
NIACIN	31.739	1.434	9.934	12.29	62.02	1523.452	48	
VITC	171.118	20.030	138.772	41.59	652.76	8213.661	48	
VITB6	2.574	.147	1.016	.63	5.67	123.538	48	
VITB12	4.952	.310	2.148	.24	10.61	237.693	48	
VITA	1236.847	79.281	549.276	447.80	2983.18	59368.667	48	
IRON	21.271	.792	5.488	11.01	32.90	1021.002	48	
CALCIUM	1474.856	62.464	432.763	375.34	2432.00	70793.083	48	
MAGNESUM	697.986	33.791	234.109	310.07	1146.42	33503.312	48	
PHOSPHOR	2608.727	99.476	689.191	1099.00	4331.57	125218.894	48	
SODIUM	6046.419	215.009	1489.628	2287.42	9155.30	290228.117	48	
POTASIUM	5202.847	201.498	1396.022	2734.01	8306.92	249736.672	48	
FOLACIN	294.691	14.721	101.987	114.34	629.14	14145.146	48	
ZINC	13.821	.846	5.864	3.28	29.27	663.389	48	

GROUP: ARMYADE SEX: FEMALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 56.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	4228.309	241.244	1805.304	1348.62	9359.95	236785.300	56	
ENERGY	2165.998	121.131	906.462	136.70	5159.85	121295.903	56	
PROTEIN	70.185	5.679	42.500	.00	245.30	3930.370	56	
CARBOHYD	318.187	18.814	140.791	34.75	758.58	17818.497	56	
FAT	70.444	4.779	35.766	.00	191.22	3944.863	56	
CHOLESTR	428.648	39.746	297.430	.00	1335.60	24004.306	56	
THIAMIN	1.728	.120	.894	.00	4.61	96.762	56	
RIBOFLAV	1.862	.170	1.275	.00	8.71	104.288	56	
NIACIN	20.506	1.761	13.175	.00	57.71	1148.322	56	
VITC	174.950	22.922	171.531	.00	702.77	9797.198	56	
VITB6	1.559	.126	.945	.00	4.12	87.295	56	
VITB12	3.524	.454	3.395	.00	20.28	197.322	56	
VITA	820.932	91.592	685.414	.00	3658.76	45972.167	56	
IRON	12.694	.879	6.576	.29	33.89	710.888	56	
CALCIUM	870.326	98.191	734.793	62.03	5631.21	48738.256	56	
MAGNESUM	350.787	21.422	160.305	42.18	920.69	19644.082	56	
PHOSPHOR	1497.197	107.820	806.849	57.26	5397.67	83843.023	56	
SODIUM	3244.529	186.142	1392.962	230.55	7241.77	181693.639	56	
POTASIUM	2808.094	192.718	1442.168	189.96	9360.76	157253.245	56	
FOLACIN	261.383	21.689	162.307	.00	833.58	14637.467	56	
ZINC	8.472	.712	5.332	.29	28.61	474.419	56	

GROUP: CONTROL SEX: MALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 48.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	7087.431	414.177	2869.503	2718.60	14450.19	340196.710	48	
ENERGY	3072.506	176.753	1224.581	724.61	5944.03	147480.286	48	
PROTEIN	112.676	8.044	55.731	9.87	302.70	5408.432	48	
CARBOHYD	390.579	24.979	173.059	54.95	784.67	18747.769	48	
FAT	119.507	7.208	49.936	5.24	228.72	5736.344	48	
CHOLESTR	637.805	53.146	368.209	15.98	1470.54	30614.635	48	
THIAMIN	2.465	.193	1.340	.52	6.69	118.336	48	
RIBOFLAV	2.599	.229	1.583	.36	7.82	124.761	48	
NIACIN	27.843	1.892	13.110	4.65	60.15	1336.440	48	
VITC	191.662	19.994	138.520	10.27	524.06	9199.767	48	
VITB6	1.967	.150	1.038	.43	4.56	94.403	48	
VITB12	4.394	.461	3.191	.00	14.87	210.907	48	
VITA	1038.042	105.669	732.095	28.35	3562.77	49826.016	48	
IRON	18.793	1.066	7.385	1.80	36.95	902.058	48	
CALCIUM	1537.449	126.781	878.364	360.80	4074.28	73797.530	48	
MAGNESUM	343.961	22.712	157.350	52.35	792.98	16510.125	48	
PHOSPHOR	1875.629	142.080	984.359	266.29	4913.94	90030.170	48	
SODIUM	4184.076	266.185	1844.186	402.13	10278.80	200835.635	48	
POTASIUM	3596.140	241.713	1674.638	673.71	8292.53	172614.700	48	
FOLACIN	273.343	20.760	143.832	.00	644.47	13120.463	48	
ZINC	12.454	.927	6.422	.43	30.94	597.793	48	

GROUP: CONTROL SEX: FEMALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 72.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	4572.864	234.143	1986.766	600.98	12514.95	329246.231	72	
ENERGY	2138.310	92.388	783.941	561.93	6162.47	153958.285	72	
PROTEIN	81.437	7.285	61.813	14.46	535.20	5863.491	72	
CARBOHYD	286.330	10.237	86.864	84.15	485.22	20615.725	72	
FAT	76.099	4.457	37.819	17.12	277.14	5479.116	72	
CHOLESTR	427.336	38.061	322.962	1.33	1552.71	30768.215	72	
THIAMIN	1.818	.116	.987	.30	4.43	130.932	72	
RIBOFLAV	1.958	.113	.962	.53	5.15	140.989	72	
NIACIN	21.284	1.697	14.399	4.15	112.92	1532.482	72	
VITC	158.727	12.361	104.885	4.06	441.90	11428.323	72	
VITB6	1.638	.125	1.057	.14	5.69	117.955	72	
VITB12	3.342	.336	2.853	.00	19.80	240.651	72	
VITA	968.887	77.278	655.725	166.04	2815.75	69759.860	72	
IRON	14.371	1.043	8.854	1.99	71.62	1034.695	72	
CALCIUM	1067.930	50.230	426.216	265.22	2644.17	76890.976	72	
MAGNESUM	242.743	11.819	100.284	57.17	649.74	17477.517	72	
PHOSPHOR	1318.178	75.066	636.960	335.94	5277.95	94908.811	72	
SODIUM	2865.569	139.920	1187.258	853.43	6609.01	206320.966	72	
POTASIUM	2686.229	145.388	1233.660	414.24	7686.99	193408.480	72	
FOLACIN	227.693	15.906	134.967	27.53	592.72	16393.925	72	
ZINC	9.114	.959	8.135	1.71	69.21	656.200	72	

GROUP: PLACEBO SEX: MALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 40.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	6322.800	279.820	1769.734	1808.80	10585.20	252911.980	40	
ENERGY	2617.994	123.862	783.370	1123.38	4244.60	104719.755	40	
PROTEIN	110.651	5.671	35.868	39.01	196.91	4426.056	40	
CARBOHYD	323.611	17.893	113.166	121.45	575.86	12944.434	40	
FAT	100.128	5.543	35.058	40.34	163.65	4005.136	40	
CHOLESTR	589.845	50.270	317.935	92.07	1117.19	23593.785	40	
THIAMIN	2.189	.192	1.214	.51	6.40	87.552	40	
RIBOFLAV	2.746	.206	1.302	.68	6.96	109.832	40	
NIACIN	27.645	1.935	12.239	4.59	67.76	1105.810	40	
VITC	162.324	23.389	147.923	8.77	584.08	6492.964	40	
VITB6	1.931	.180	1.139	.32	6.44	77.227	40	
VITB12	5.268	.453	2.867	.80	14.55	210.711	40	
VITA	1094.735	134.500	850.655	197.21	3988.30	43789.414	40	
IRON	18.928	1.375	8.695	6.26	52.42	757.134	40	
CALCIUM	1574.263	92.368	584.187	518.80	2648.17	62970.503	40	
MAGNESUM	309.427	17.420	110.172	88.03	511.85	12377.085	40	
PHOSPHOR	1792.811	84.066	531.678	721.37	2750.11	71712.459	40	
SODIUM	4216.512	226.127	1430.153	1549.91	7595.35	168660.495	40	
POTASIUM	3566.209	190.622	1205.599	1221.78	6346.48	142648.363	40	
FOLACIN	290.342	26.269	166.138	84.34	832.07	11613.662	40	
ZINC	11.752	.568	3.590	4.89	21.72	470.081	40	

GROUP: PLACBO SEX: FEMALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 48.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	5256.255	252.705	1750.789	1456.15	10654.05	252300.240	48	
ENERGY	2829.031	108.183	749.515	861.16	4348.24	135793.493	48	
PROTEIN	106.727	5.250	36.372	26.32	183.59	5122.886	48	
CARBOHYD	362.725	16.103	111.565	107.86	629.53	17410.794	48	
FAT	108.307	5.015	34.748	31.13	174.16	5198.750	48	
CHOLESTR	559.049	41.821	289.743	10.22	1240.57	26834.356	48	
THIAMIN	2.777	.177	1.229	.70	5.92	133.273	48	
RIBOFLAV	2.523	.123	.854	.88	4.12	121.114	48	
NIACIN	27.780	1.629	11.283	7.60	62.15	1333.440	48	
VITC	203.933	24.343	168.656	19.69	907.95	9788.785	48	
VITB6	2.307	.172	1.191	.46	6.11	110.723	48	
VITB12	3.686	.222	1.539	.55	7.16	176.924	48	
VITA	1118.990	93.689	649.096	305.19	3107.07	53711.526	48	
IRON	17.450	.790	5.477	3.13	31.02	837.612	48	
CALCIUM	1344.668	68.564	475.027	525.27	2417.63	64544.055	48	
MAGNESUM	332.599	15.567	107.849	125.62	620.48	15964.776	48	
PHOSPHOR	1687.748	75.909	525.911	383.69	2797.78	81011.914	48	
SODIUM	4217.466	201.988	1399.417	984.76	8077.79	202438.376	48	
POTASIUM	3585.478	179.632	1244.530	767.94	6430.13	172102.958	48	
FOLACIN	273.589	15.048	104.254	18.16	486.35	13132.273	48	
ZINC	10.453	.509	3.524	1.86	18.07	501.726	48	

GROUP: NBC SEX: MALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 72.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	6561.537	290.335	2463.576	2120.14	14008.20	472430.670	72	
ENERGY	2964.570	131.455	1115.429	597.54	5738.16	213449.057	72	
PROTEIN	100.694	5.083	43.131	9.58	212.71	7249.981	72	
CARBOHYD	409.756	19.113	162.179	110.02	799.21	29502.442	72	
FAT	103.927	5.160	43.788	16.13	221.38	7482.775	72	
CHOLESTR	496.097	35.451	300.814	26.88	1200.32	35718.987	72	
THIAMIN	2.675	.156	1.325	.18	7.12	192.633	72	
RIBOFLAV	2.479	.116	.984	.33	6.36	178.490	72	
NIACIN	26.403	1.314	11.149	5.20	58.45	1901.005	72	
VITC	151.906	15.637	132.684	13.72	636.21	10937.201	72	
VITB6	2.053	.137	1.161	.31	6.31	147.816	72	
VITB12	3.374	.265	2.249	.00	12.53	242.915	72	
VITA	1019.384	76.124	645.934	126.28	3454.05	73395.680	72	
IRON	16.488	.730	6.197	3.20	34.31	1187.144	72	
CALCIUM	1209.930	62.310	528.721	111.60	3915.34	87114.929	72	
MAGNESUM	308.667	14.141	119.988	110.81	596.58	22224.035	72	
PHOSPHOR	1840.798	85.490	725.409	211.44	4323.17	132537.437	72	
SODIUM	5298.660	220.670	1872.448	1218.67	10743.43	381503.509	72	
POTASIUM	3359.507	156.216	1325.533	1105.67	7127.23	241884.495	72	
FOLACIN	216.479	11.863	100.660	10.28	445.63	15586.461	72	
ZINC	9.642	.469	3.977	1.62	22.15	694.196	72	

GROUP: NBC SEX: FEMALE
NUMBER OF VALID OBSERVATIONS (LISTWISE) = 56.00

VARIABLE	MEAN	S.E. MEAN	STD DEV	MINIMUM	MAXIMUM	SUM	VALID N	LABEL
QUANTITY	5388.710	293.209	2194.175	1214.09	11904.44	301767.740	56	
ENERGY	2367.015	97.660	730.817	1018.43	3895.41	132552.816	56	
PROTEIN	74.940	3.930	29.408	18.41	144.91	4196.647	56	
CARBOHYD	360.831	17.106	128.009	136.88	678.33	20206.528	56	
FAT	71.350	3.866	28.927	16.70	128.67	3995.611	56	
CHOLESTR	436.828	34.316	256.798	55.41	904.10	24462.365	56	
THIAMIN	1.531	.127	.954	.27	4.55	85.753	56	
RIBOFLAV	1.787	.102	.766	.31	3.93	100.079	56	
NIACIN	19.406	1.280	9.579	5.49	41.56	1086.710	56	
VITC	158.914	20.632	154.395	1.09	740.73	8899.203	56	
VITB6	1.368	.097	.722	.30	3.60	76.622	56	
VITB12	3.459	.250	1.872	.09	8.16	193.706	56	
VITA	769.659	75.684	566.364	38.47	2552.57	43100.879	56	
IRON	12.117	.639	4.781	4.87	27.46	678.568	56	
CALCIUM	894.234	42.050	314.675	127.96	1591.81	50077.103	56	
MAGNESUM	237.738	12.773	95.581	77.20	621.52	13313.354	56	
PHOSPHOR	1527.063	59.316	443.882	555.80	2538.49	85515.515	56	
SODIUM	4077.665	302.804	2265.981	933.70	11633.95	228349.218	56	
POTASIUM	2645.533	156.754	1173.042	456.05	7105.80	148149.841	56	
FOLACIN	220.904	13.735	102.781	32.19	520.33	12370.643	56	
ZINC	14.017	3.527	26.394	1.73	127.33	784.940	56	

APPENDIX K - MEAN NUTRIENT INTAKE NORMALIZED TO BODY WEIGHT

ENERGY INTAKE NORMALIZED TO BODY WEIGHT (KCAL/KG) FOR MALES AND FEMALES

POOLED SUBJECTS:

VARIATE	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DEP_VAR	440	37.22	0.6719	14.09	37.80	89.05	2.100

MARGINALS

FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
GROUP	ARMYADE	104	41.2866	1.3990	14.2671	41.7217	78.4900	2.1000
	CONTROL	120	33.8360	1.3133	14.3862	34.2951	89.0500	7.8300
	PLACEBO	88	39.7326	1.5184	14.2437	39.7310	73.9500	10.8700
	NBC	128	35.3695	1.1056	12.5087	35.4529	74.3700	7.2300
SEX	MALE	216	39.0877	1.0319	15.1654	39.6255	78.4900	7.2300
	FEMALE	224	35.4239	0.8522	12.7551	35.9749	89.0500	2.1000
DAY	* 1.0000	55	37.2756	2.1879	16.2257	37.6134	78.4900	10.8100
	* 2.0000	55	41.4678	1.9552	14.5002	42.5618	76.7000	7.8300
	* 3.0000	55	43.7125	2.0045	14.8660	44.3420	89.0500	17.2200
	* 4.0000	55	35.8925	1.6953	12.5729	36.3392	62.4600	12.6400
	* 5.0000	55	35.7345	1.8824	13.9606	36.5848	69.3100	2.1000
	* 6.0000	55	38.3733	1.9937	14.7854	38.5278	74.4600	6.8500
	* 7.0000	55	30.5913	1.4225	10.5492	31.0546	59.1300	8.7300
	* 8.0000	55	34.7322	1.4755	10.9423	35.3780	57.9500	10.2800

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GROUP ARMYADE

==>
SEX MALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	6	48.5217	8.4972	20.8139	48.5217	78.4900	31.2500
	* 2.0000	6	51.2133	5.7588	14.1060	51.2133	76.7000	40.4800
	* 3.0000	6	60.0683	2.9816	7.3033	60.0683	67.1400	50.6800
	* 4.0000	6	40.3950	4.2024	10.2936	40.3950	51.4100	23.5500
	* 5.0000	6	44.2033	5.9066	14.4682	44.2033	69.3100	25.4600
	* 6.0000	6	48.4650	3.1723	7.7706	48.4650	60.8500	39.2500
	* 7.0000	6	46.7467	4.0226	9.8533	46.7467	59.1300	37.1400
	* 8.0000	6	39.4083	2.4936	6.1082	39.4083	50.0200	33.5200

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SEX FEMALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	7	31.8100	2.1491	5.6859	31.8100	41.0100	23.2400
	* 2.0000	7	43.4343	2.6254	6.9462	43.4343	53.3800	32.9700
	* 3.0000	7	47.8443	3.5015	9.2640	47.8443	61.5400	33.1700
	* 4.0000	7	31.5186	4.2927	11.3574	31.5186	50.1800	16.6700
	* 5.0000	7	36.7543	7.9945	21.1515	36.7543	63.0300	2.1000
	* 6.0000	7	39.2457	7.4186	19.6277	39.2457	74.4600	6.8500
	* 7.0000	7	28.1314	2.9371	7.7709	28.1314	39.6100	18.7600
	* 8.0000	7	29.7871	2.8054	7.4223	29.7871	39.1800	18.2000

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GROUP CONTROL

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SEX MALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	6	34.7917	8.8469	21.6704	34.7917	71.1900	11.7300
	* 2.0000	6	46.5967	6.5645	16.0798	46.5967	64.5700	18.0300
	* 3.0000	6	44.4300	6.2943	15.4177	44.4300	64.0200	18.7000
	* 4.0000	6	29.5100	4.6616	11.4186	29.5100	44.3100	13.5800
	* 5.0000	6	39.6633	7.3313	17.9579	39.6633	62.0400	10.9600
	* 6.0000	6	29.8067	6.6428	16.2714	29.8067	58.7900	9.6700
	* 7.0000	6	28.7700	4.9165	12.0430	28.7700	46.7900	12.5200
	* 8.0000	6	39.1583	5.1682	12.6594	39.1583	57.9500	27.1400

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SEX FEMALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	9	30.7411	3.7895	11.3686	30.7411	50.1800	10.8100
	* 2.0000	9	30.5844	4.3155	12.9464	30.5844	53.0600	7.8300
	* 3.0000	9	39.1144	6.8218	20.4653	39.1144	89.0500	17.2200
	* 4.0000	9	32.1311	4.6031	13.8093	32.1311	54.7000	12.6400
	* 5.0000	9	28.4900	3.0480	9.1440	28.4900	40.9300	15.6500
	* 6.0000	9	36.3767	5.0510	15.1530	36.3767	56.7900	10.8000
	* 7.0000	9	25.0022	2.8515	8.5546	25.0022	39.0200	8.7300
	* 8.0000	9	33.5556	2.5618	7.6853	33.5556	41.4500	17.1200

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GROUP PLACEBO

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SEX MALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	6	38.9500	5.4439	13.3347	38.9500	56.0800	24.3600
	* 2.0000	6	44.7467	8.6674	21.2307	44.7467	69.0200	13.6200
	* 3.0000	6	42.0200	8.2670	20.2501	42.0200	73.9500	24.2300
	* 4.0000	6	42.0533	5.9417	14.5541	42.0533	62.4600	27.8300
	* 5.0000	6	32.9300	4.8389	11.8527	32.9300	50.1700	21.0900
	* 6.0000	6	42.0267	7.1422	17.4947	42.0267	71.2800	21.7400
	* 7.0000	6	34.6117	5.0040	12.2573	34.6117	50.2400	20.2900
	* 8.0000	6	40.6500	6.0210	14.7484	40.6500	58.3000	16.9800

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SEX FEMALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	5	39.4080	9.8896	22.1138	39.4080	70.3900	15.9400
	* 2.0000	5	45.9240	5.5655	12.4448	45.9240	59.6000	28.4300
	* 3.0000	5	43.4780	4.3273	9.6761	43.4780	59.9900	35.0300
	* 4.0000	5	41.9960	5.1201	11.4489	41.9960	56.5500	31.2300
	* 5.0000	5	43.1280	3.8755	8.6659	43.1280	54.5100	33.5000
	* 6.0000	5	39.0120	3.7792	8.4506	39.0120	53.8400	32.7000
	* 7.0000	5	26.8960	3.7611	8.4101	26.8960	37.9900	15.3800
	* 8.0000	5	37.8660	7.4306	16.6154	37.8660	53.1100	10.8700

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GROUP NBC

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SEX MALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	9	41.7044	6.4683	19.4048	41.7044	74.3700	23.2900
	* 2.0000	9	35.2522	5.1529	15.4587	35.2522	62.0300	20.2800
	* 3.0000	9	38.1422	4.5632	13.6897	38.1422	61.3700	21.9400
	* 4.0000	9	35.3922	4.3684	13.1051	35.3922	55.6300	14.8400
	* 5.0000	9	31.3611	3.9737	11.9210	31.3611	45.3800	7.2300
	* 6.0000	9	39.2700	5.1446	15.4338	39.2700	67.0100	17.2000
	* 7.0000	9	28.6889	2.5206	7.5619	28.6889	42.2200	18.2700
	* 8.0000	9	28.4689	3.5556	10.6669	28.4689	42.4800	10.2800

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SEX FEMALE
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FACTOR	LEVEL	COUNT	MEAN	STDERROR	STD_DEV	WTD_MEAN	MAXIMUM	MINIMUM
DAY	* 1.0000	7	34.9800	4.8178	12.7467	34.9800	58.1400	21.4500
	* 2.0000	7	42.7429	2.7041	7.1544	42.7429	54.7900	36.1700
	* 3.0000	7	39.6386	2.9205	7.7268	39.6386	50.6900	28.6900
	* 4.0000	7	37.7171	4.9539	13.1069	37.7171	56.4900	17.3400
	* 5.0000	7	36.1486	4.5672	12.0838	36.1486	60.8400	26.3600
	* 6.0000	7	34.0200	4.8660	12.8743	34.0200	47.3100	15.8400
	* 7.0000	7	29.5900	2.4163	6.3931	29.5900	40.0400	21.5000
	* 8.0000	7	34.1300	3.5368	9.3575	34.1300	45.5900	22.4800

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=======================================================================
WITHIN EFFECT: OBS: WITHIN CASE MEAN

EFFECT   VARIATE        STATISTIC             F          DF          P
-----------------------------------------------------------------------
 OVALL: GRAND MEAN
        DEP_VAR
                  SS=     6Ø5639.44ØØ37
                  MS=     6Ø5639.44ØØ37     953.81     1,    47  Ø.ØØØØ
 G: GROUP
        DEP_VAR
                  SS=       3988.1948Ø2
                  MS=       1329.398267       2.Ø9     3,    47  Ø.1137
 S: SEX
        DEP_VAR
                  SS=       1412.219415
                  MS=       1412.219415       2.22     1,    47  Ø.1426
 GS
        DEP_VAR
                  SS=       26Ø9.955226
                  MS=        869.985Ø75       1.37     3,    47  Ø.2634

 ERROR
        DEP_VAR
                  SS=      29843.59443866
                  MS=        634.97ØØ9444

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WITHIN EFFECT: D: DAY

EFFECT   VARIATE        STATISTIC                  F          DF          P
--------------------------------------------------------------------------
 D
      DEP_VAR
               TSQ=        66.1796            8.25      7,    41  0.0000
           WCP SS=        6411.665689
           WCP MS=         915.952241         8.00      7,   329  0.0000
           GREENHOUSE-GEISSER ADJ. DF         8.00   6.00, 281.84 0.0000
           HUYNH-FELDT ADJUSTED DF            8.00   7.00, 329.00 0.0000
 (D) X (G: GROUP)
      DEP_VAR
               LRATIO=  0.623887              1.01     21, 118.28 0.4620
               TRACE=   0.528736
               TZSQ=       22.7356
                   CHISQ =     9.70                       9.924  0.4606
               MXROOT=  0.237596                                 0.4919
           WCP SS=        2424.316423
           WCP MS=         115.443639         1.01     21,   329  0.4517
           GREENHOUSE-GEISSER ADJ. DF         1.01 17.99, 281.84 0.4495
           HUYNH-FELDT ADJUSTED DF            1.01 21.00, 329.00 0.4517
 (D) X (S: SEX)
      DEP_VAR
               TSQ=        5.21807            0.65      7,    41  0.7119
           WCP SS=         512.699077
           WCP MS=          73.242725         0.64      7,   329  0.7226
           GREENHOUSE-GEISSER ADJ. DF         0.64   6.00, 281.84 0.6980
           HUYNH-FELDT ADJUSTED DF            0.64   7.00, 329.00 0.7226
 (D) X (GS)
      DEP_VAR
               LRATIO=  0.640595              0.94     21, 118.28 0.5354
               TRACE=   0.518484
               TZSQ=       22.2948
                   CHISQ =     9.46                       9.924  0.4825
               MXROOT=  0.298158                                 0.2240
           WCP SS=        2383.453638
           WCP MS=         113.497792         0.99     21,   329  0.4728
           GREENHOUSE-GEISSER ADJ. DF         0.99 17.99, 281.84 0.4690
           HUYNH-FELDT ADJUSTED DF            0.99 21.00, 329.00 0.4728

 ERROR
      DEP_VAR
           WCP SS=      37645.33611597
           WCP MS=        114.42351403

           GGI EPSILON     0.85665
           H-F EPSILON     1.00000
```

APPENDIX L
ENERGY FROM ALL FLUIDS

Energy from all fluids (water, test beverage, and other)

DAY	GROUPS ARMYADE (n=13)	CONTROL (n=15)	PLACEBO (n=11)	NBC (n=16)	MEAN (n=55)
1	538±72	471±118	417±99	836±108	582±56
2	889±122	659±106	569±90	931±128	775±60
3	1007±108	613±118	456±93	938±107	769±61
4	752±107	561±92	545±94	930±140	710±60
5	743±106	546±121	618±112	765±87	670±54
6	886±189	509±129	549±100	884±107	715±70
7	617±87	442±105	440±56	714±80	562±46
8	558±99	473±62	488±71	727±73	570±40
$\bar{x}$±SE	749±43	534±38	510±32	841±37	669±20

Values are mean±1SEM.

APPENDIX M - SODIUM INTAKE (mg/day)

Sodium Intake from All Foods and Fluids Eaten during 8 Days in the Heat (mg/day).

	GROUPS				
DAY	ARMYADE (n=13)	CONTROL (n=15)	PLACEBO (n=11)	NBC (n=16)	MEAN (n=55)
1	4130±499	3276±425	3903±385	5315±473	4196±246
2	5445±506	3779±437	4702±445	5562±677	4876±285
3	5067±551	3958±551	4331±417	4708±422	4513±248
4	4089±486	3184±314	4425±374	5391±625	4288±263
5	4202±626	3769±422	4468±565	4060±361	4096±238
6	4669±664	3269±407	4467±342	4952±505	4329±261
7	4638±658	2684±398	3548±321	3966±395	3691±245
8	4062±437	3225±338	3892±506	4162±653	3829±254
$\bar{x}$±SE	4538±197	3393±147	4217±150	4764±189	4227±91

Values are mean±1SEM.

APPENDIX N - HYDRATION STATUS TABLES

PERCENT CHANGE IN BODY WEIGHT FROM PRE-DEPLOYMENT.

	GROUPS			
DAY	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1AM	-1.02±0.39	-0.39±0.22	-0.95±0.31	-0.33±0.19
1PM	-0.93±0.43	-0.54±0.31	-0.57±0.44	0.19±0.28
2AM	-1.34±0.35	-0.85±0.32	-1.40±0.48	-0.72±0.31
2PM	-0.48±0.42	0.08±0.35	-0.08±0.64	0.23±0.28
3AM	-1.47±0.42	-0.57±0.34	-1.33±0.60	-0.42±0.28
3PM	-0.79±0.37	-0.02±0.44	-0.34±0.61	0.30±0.34
4AM	-1.34±0.35	-0.66±0.36	-1.24±0.65	-0.48±0.31
4PM	-0.81+0.40	-0.16±0.33	-0.19±0.55	0.27±0.36
5AM	-1.66±0.33	-0.65±0.43	-1.23±0.91	-0.58±0.30
5PM				
6AM	-1.45±0.33	-0.71±0.37	-0.70±0.90	-0.41±0.37
6PM	-0.74±0.44	-0.07±0.40	-0.12±0.63	0.24±0.37
7AM	-1.00±0.35	-0.77±0.38	-0.49±0.61	-0.34±0.42
7PM	-1.11±0.25	-0.48±0.35	-0.55±0.55	-0.32±0.32
8AM	-1.03±0.29	-0.91±0.37	-0.77±0.48	-0.49±0.29
8PM	-0.95±0.35	-0.86±0.35	-0.66±0.58	-0.56±0.31

Values are mean±1SEM.

EFFECTS OF CONSUMPTION OF CARBOHYDRATE-ELECTROLYTE BEVERAGES ON DIURNAL URINARY EXCRETION OF POTASSIUM (mEq/L).

	GROUPS			
DAY	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1AM	39.8±4.7	52.9±6.8	41.6±6.8	42.3±5.4
1PM	59.4±5.9	63.4±9.2	38.0±6.9	48.5±6.3
2AM	38.9±3.0	37.6±4.0	42.8±7.1	27.9±2.9
2PM	74.5±8.0	57.3±8.6	38.8±8.4	42.1±6.2
3AM	41.6±5.1	44.1±6.4	32.2±6.4	36.5±4.8
3PM	73.5±6.0	52.0±7.1	46.3±6.5	49.4±8.3
4AM	48.3±6.3	39.5±4.3	39.1±6.3	36.8±5.1
4PM	82.3±13.2	47.6±6.7	61.0±12.7	34.0±5.3
5AM	57.5±7.8	39.2±4.5	33.5±5.9	32.9±5.2
5PM				
6AM	44.9±6.1	35.2±6.3	45.8±8.8	26.8±4.2
6PM	70.3±7.5	49.2±7.8	45.0±11.9	31.4±5.1
7AM	39.3±5.0	39.8±5.3	29.6±6.0	23.6±3.9
7PM	53.0±5.7	47.3±7.7	49.5±11.1	36.9±4.8
8AM	46.9±7.7	35.6±4.4	28.6±4.2	34.1±5.0
8PM	48.8±5.7	53.1±6.2	49.6±8.9	42.3±4.9

Values are mean±1SEM.

EFFECTS OF CONSUMPTION OF CARBOHYDRATE-ELECTROLYTE BEVERAGES AND CONTROLS ON DIURNAL EXCRETION OF SODIUM (mEq/L).

	GROUPS			
DAY	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1AM	134.2±15.8	101.2±12.5	111.2±14.3	111.2±12.7
1PM	158.7±15.8	92.1±14.4	76.8±14.2	107.7±13.0
2AM	131.1±12.1	101.8±12.9	82.3±10.3	93.5±12.7
2PM	144.8±14.3	83.9±15.7	53.8±11.4	96.1±16.2
3AM	104.6±10.9	93.9±12.1	76.4±10.5	109.3±16.6
3PM	139.5±12.5	80.3±12.6	85.6±16.7	108.7±16.8
4AM	130.9±15.4	99.9±10.5	104.4±11.5	104.8±12.5
4PM	96.6±16.8	72.9±12.9	61.3±13.2	86.8±13.5
5AM	116.0± 8.2	89.1± 9.9	83.6±18.0	86.5±10.2
5PM				
6AM	133.7±15.4	109.9±11.4	128.8±15.8	103.2±11.2
6PM	121.4±13.4	89.7±12.8	84.3±21.5	108.8±14.8
7AM	111.0±13.8	88.9±10.2	64.5±10.2	79.7± 8.5
7PM	152.9±16.7	79.3±11.5	73.1±11.1	126.1±14.3
8AM	104.1±12.8	87.6± 8.7	79.6±10.4	116.7±11.8
8PM	146.7±14.6	110.6± 8.3	104.0±13.2	135.7±13.2

Values are mean±1SEM.

URINARY CREATININE (mg/dl) EXCRETION AS INDICATORS OF HYDRATION.

	GROUPS			
DAY	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1AM	183.3±21.9	201.4±24.4	178.0±27.1	176.2±16.5
1PM	176.5±15.2	239.7±29.6	126.4±25.5	166.5±27.6
2AM	198.5±21.0	210.8±27.3	160.6±22.4	147.9±14.3
2PM	164.9±13.3	236.7±36.3	201.0±41.0	245.4±42.5
3AM	161.0±16.9	171.8±19.8	121.3±20.1	144.6±14.4
3PM	178.4±15.6	180.7±25.2	113.9±11.5	153.0±22.3
4AM	204.1±19.3	203.8±22.0	173.3±15.3	166.8±18.6
4PM	184.8±32.5	189.8±29.1	156.6±31.7	120.1±16.2
5AM	228.1±19.5	219.3±24.3	128.3±22.9	162.7±26.5
5PM				
6AM	185.4±20.8	165.1±21.5	169.3±16.4	143.7±20.6
6PM	178.9±20.5	176.0±28.0	118.3±27.2	116.2±12.3
7AM	131.0±17.7	184.6±23.0	110.9±20.9	107.5±14.7
7PM	167.6±16.9	161.9±26.3	109.2±21.6	126.2±14.5
8AM	157.4±19.8	195.8±27.0	125.0±19.3	149.8±26.8
8PM	130.3±19.1	155.9±21.4	140.5±25.8	156.3±27.3

Values are mean±1SEM.

DIURNAL URINARY SODIUM TO POTASSIUM RATIOS AS INDICATORS OF HYDRATION.

	GROUPS			
DAY	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1AM	3.53±0.30	3.00±0.43	2.48±0.62	3.60±0.45
1PM	2.86±0.32	2.59±0.33	3.36±0.69	3.12±0.38
2AM	3.18±0.55	2.75±0.33	3.25±0.54	3.20±0.30
2PM	2.56±0.42	2.46±0.28	2.67±0.39	3.07±0.32
3AM	3.82±0.71	4.08±0.52	3.44±0.49	4.40±0.31
3PM	3.11±0.44	2.61±0.31	2.67±0.37	4.14±0.53
4AM	2.74±0.37	2.72±0.22	3.11±0.37	4.11±0.35
4PM	3.90±0.55	2.69±0.40	3.37±0.39	3.20±0.68
5AM	2.98±0.44	1.71±0.24	2.30±0.31	2.46±0.27
5PM				
6AM	2.01±0.20	1.63±0.20	2.04±0.41	2.61±0.39
6PM	1.37±0.22	1.54±0.20	1.24±0.20	2.93±0.40
7AM	1.71±0.22	1.79±0.18	1.64±0.25	3.16±0.30
7PM	2.06±0.31	2.02±0.20	2.61±0.45	3.93±0.58
8AM	3.31±0.54	2.09±0.23	2.15±0.35	3.75±0.33
8PM	3.74±0.66	2.70±0.40	2.66±0.40	3.56±0.28

Values are mean±1SEM.

APPENDIX

BODY WEIGHT (kg) CHANGES DURING 8 DAYS OF WORK IN THE HEAT.

	GROUPS			
DAY	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1AM	67.76±3.13	78.11±4.22	74.15±4.09	78.26±3.73
1PM	67.77±3.04	77.91±4.10	74.36±3.99	78.61±3.69
2AM	67.51±3.05	77.69±4.13	73.77±4.03	77.94±3.71
2PM	68.06±3.03	78.39±4.13	74.69±3.97	78.64±3.69
3AM	67.41±3.04	77.95±4.19	73.77±3.97	78.19±3.73
3PM	67.92±3.14	78.31±4.14	74.47±3.90	78.66±3.63
4AM	67.53±3.09	77.85±4.13	73.79±3.87	78.11±3.66
4PM	67.91±3.15	78.26±4.20	74.65±4.02	78.72±3.71
5AM	67.29±3.05	77.85±4.13	73.89±4.06	78.05±3.67
5PM				
6AM	67.44±3.07	77.80±4.12	74.35±4.24	78.14±3.64
6PM	67.94±3.12	78.27±4.10	74.77±4.20	78.64±3.65
7AM	67.73±3.05	77.75±4.12	74.43±4.08	78.21±3.66
7PM	67.69±3.10	77.95±4.09	74.45±4.19	78.23±3.64
8AM	67.74±3.08	77.64±4.11	74.24±4.09	78.10±3.65
8PM	67.84±3.19	77.67±4.09	74.37±4.19	78.01±3.61

Values are mean±1SEM.

PERCENT CHANGE IN BODY WEIGHT DURING THE WORK DAY (0700-1600 HRS).

	GROUPS			
DAY	ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1	-0.048±0.201	-0.168±0.266	0.381±0.271	0.519±0.248
2	0.879±0.250	0.995±0.184	1.334±0.281	0.960±0.161
3	0.638±0.333	0.651±0.248	0.952±0.435	0.741±0.277
4	0.538±0.277	0.459±0.187	1.086±0.332	0.893±0.284
5				
6	0.804±0.238	0.668±0.219	0.559±0.382	0.707±0.296
7	-0.095±0.299	0.363±0.286	-0.168±0.259	0.082±0.326
8	0.078±0.212	0.036±0.187	0.014±0.387	0.018±0.231

Values are mean±1SEM.

APPENDIX

DIURNAL URINARY SPECIFIC GRAVITY MEASUREMENTS DURING 8 DAYS IN THE HEAT.

DAY	GROUPS ARMYADE (n=14)	CONTROL (n=17)	PLACEBO (n=12)	NBC (n=18)
1AM	1.022±0.002	1.022±0.002	1.020±0.002	1.020±0.002
1PM	1.022±0.001	1.024±0.002	1.017±0.003	1.019±0.002
2AM	1.024±0.002	1.022±0.002	1.020±0.002	1.018±0.001
2PM	1.024±0.001	1.022±0.003	1.016±0.002	1.018±0.002
3AM	1.023±0.002	1.022±0.002	1.017±0.002	1.019±0.002
3PM	1.024±0.002	1.021±0.002	1.016±0.002	1.019±0.002
4AM	1.025±0.002	1.024±0.002	1.022±0.001	1.020±0.002
4PM	1.022±0.003	1.022±0.003	1.020±0.003	1.016±0.002
5AM	1.025±0.001	1.024±0.002	1.018±0.002	1.018±0.002
5PM				
6AM	1.021±0.002	1.019±0.002	1.021±0.002	1.016±0.002
6PM	1.022±0.002	1.021±0.003	1.016±0.003	1.016±0.002
7AM	1.018±0.002	1.020±0.002	1.015±0.002	1.013±0.001
7PM	1.022±0.002	1.018±0.003	1.014±0.002	1.017±0.002
8AM	1.019±0.002	1.020±0.002	1.017±0.002	1.018±0.002
8PM	1.020±0.002	1.022±0.002	1.019±0.003	1.019±0.002

Values are mean±1SEM.

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